PROJECT FILE COPY #1

REPORT NUMBER 144

FEBRUARY 1964

FUSELAGE STRUCTURAL ANALYSIS

VOLUME III

FRAMES, BULKHEADS AND FITTINGS

XV-5A

LIFT FAN FLIGHT RESEARCH AIRCRAFT PROGRAM

CONTRACT NUMBER DA44-177-TC-715

GENERAL ELECTRIC

Report Number 144
February 1964

FUSELAGE STRUCTURAL ANALYSIS

Volume III

FRAMES, BULKHEADS & FITTINGS

XV-5A Lift Fan

Flight Research Aircraft Program

Advanced Engine and Technology Department

General Electric Company

Cincinnati, Ohio 45215

CONTENTS

INTRODUCTION

The structural analysis of the Model XV-5A fuselage frames, bulkheads, fittings and miscellaneous components are presented in this report. The Model XV-5A is a U.S.Army V/STOL lift fan research aircraft.

A summary type load analysis is presented for each component, with the primary intent of showing the structural configuration, final critical loading and unusual assumptions made. Structural adequacy of many of the primary components has been demonstrated by proof tests.

Structural analysis on the fuselage forward and aft box structures is given in Volume I of this report, and the analyses for the fuselage center section and propulsion system mounts are presented in Volume II.

BULKHEAD FUSELAGE STATION 35

(Drawings 143F084 and 143F070)

The bulkhead at Fuselage Station 35 ties the two pitch fan support beams together and distributes shear from the nose fairing into the box beams. The pitch fan thrust diverter door forward pivot fitting is also mounted on this bulkhead.

Nose Fairing Side Shear = 464# Condition LG-3

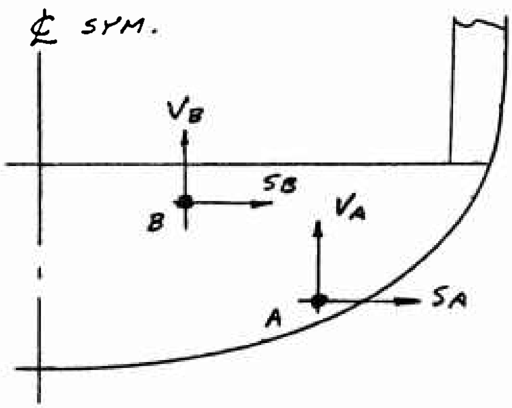
Nose Fairing Vertical Shear = -1077# Condition F-5P

Load applied to forward pivot fitting by thrust diverter door = 750# (Door @ 45° open position, load acting 20° inboard from vertical).

BULKHEAD FUSELAGE STATION 85

(Drawings 143F087 and 143F071)

The bulkhead at Fuselage Station 85 supports the pitch fan thrust diverter door aft pivot fitting, and the pivot for a bellcrank which is part of the diverter door actuating mechanism. Ultimate loads applied to the pivots, for two critical door positions, are shown below.



A : DOOR PIVOT

B : BELLCRANK PIVOT

COND. I — DOOR 45° OPEN

V_A = 176 # V_B = -3227 #
S_A = 804 # S_B = -310 #

COND. II — DOOR 81° OPEN

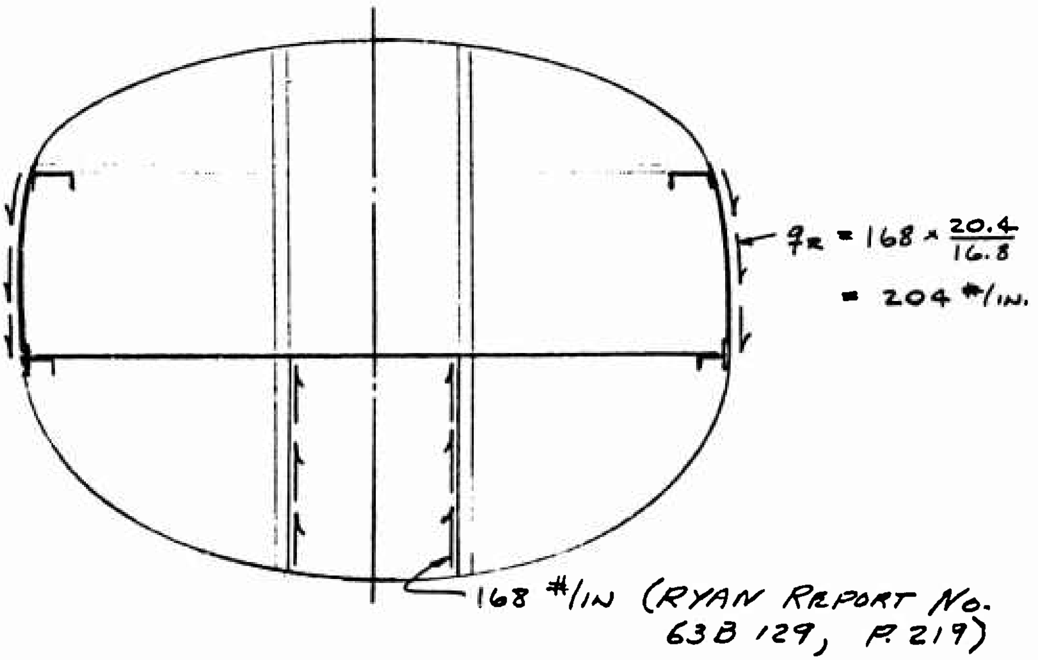
V_A = 868 # V_B = -3220 #
S_A = 438 # S_B = 123 #

BULKHEAD FUSELAGE STATION 91

(Drawing 143F005)

Bulkhead Fuselage Station 91 provides transition from the nose structure to the cockpit region structure. Loads from the pitch fan box beams are redistributed to the primary structure aft by bulkhead Fuselage Station 91. Also, the bulkhead redistributes loads from the forward ends of the wheel-well side beams to the fuselage primary structure. Other loads are applied by the windshield centerline frame, pitch fan aft mount truss, control system bracket and pitch fan diverter door mechanism brackets.

Loads for the critical condition; redistribution of wheel-well loads, are shown below. Three-point spring-back condition is critical.

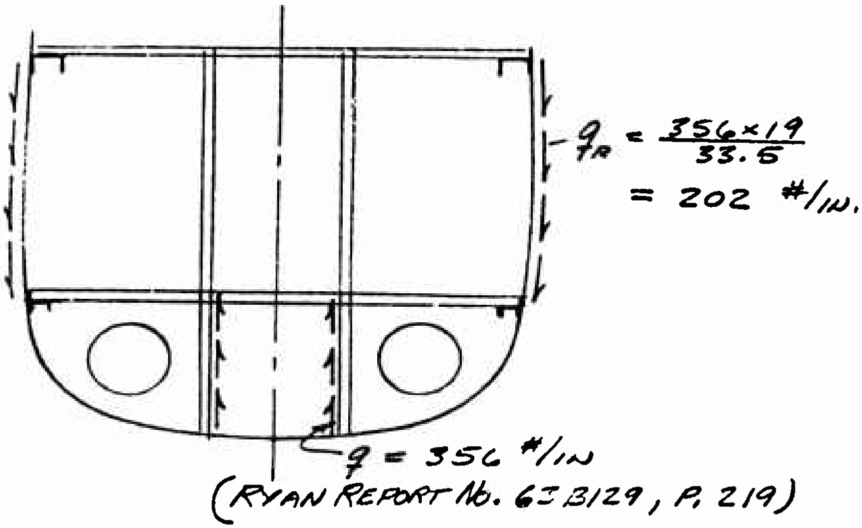


CANTED BULKHEAD FUSELAGE STATION 145.3

(Drawing 143F006)

The canted bulkhead redistributes side shear and torque from open cockpit region to the closed box section aft. Shears from the aft ends of the wheel-well beams are distributed to the aft box section. The aft end of the cockpit is closed by the canted bulkhead, which also supports the seat mount rails. The upper portion of the bulkhead incorporates the canopy hinge support structure.

Loads for the critical condition; three-point spin-up condition, are shown below.



BULKHEAD FUSELAGE STATION 165.2

(Drawing 143F078)

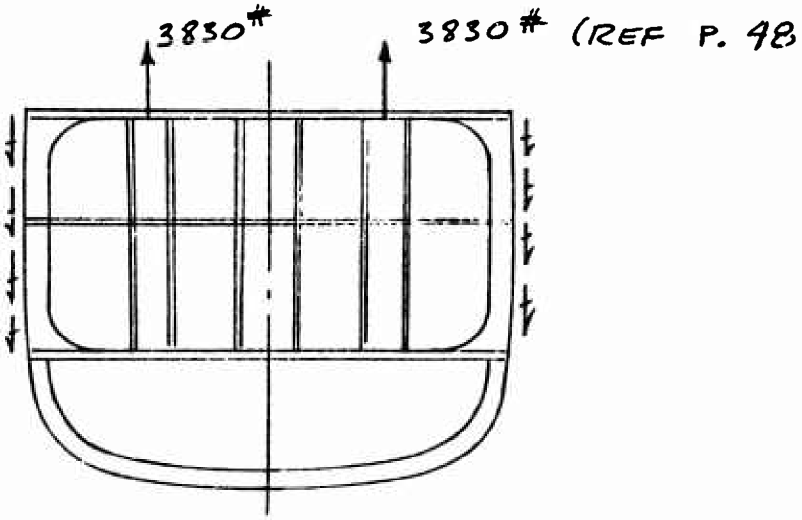
The web of bulkhead Fuselage Station 165.2 supports the forward end the main fuel cell. Vertical loads are applied to the bulkhead by the aft ends of brackets, which back up the upper portion of the North American seat mount beams.

Critical loads are summarized:

Fuel Pressure: Crash landing condition.

Ult. Horizontal Load Factor = 8

Ult. $p = (214 - 165.2)\,\frac{6.5}{231} \times 8 = 11$ psi



FRAME FUSELAGE STATION 177.2

(Drawing 143F079)

The frame at Fuselage Station 177.2 functions as a stiffening member for the fuel cell liner. The loading consists of internal pressure applied by the fuel. Two critical conditions are considered; horizontal crash landing and 6 g maneuver.

CRASH LANDING:

$$\text{ULT. } p = (214 - 177.2)\frac{6.5}{231} \times 8 = 8.34 \text{ psi}$$

FRAME LOADED WIDTH = 12 IN.

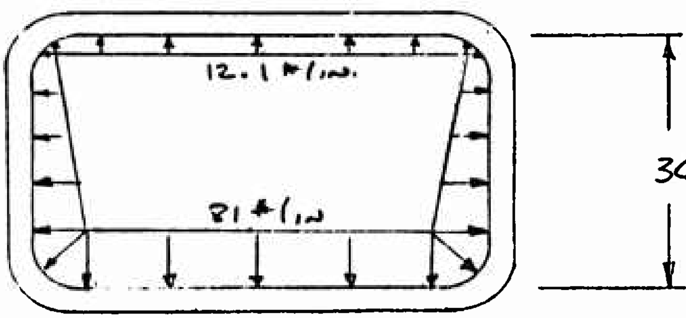
$$w = 8.34 \times 12 = 100 \text{ \#/IN. UNIFORM LOADING}$$

6 g MANEUVER:

VERTICAL HEAD = 40 IN.

$$\text{ULT. } p_{MAX} = 40 \times \frac{6.5}{231} \times 6 = 6.75 \text{ psi}$$

$$w_{MAX} = 6.75 \times 12 = 81 \text{ \#/IN.}$$



FRAME FUSELAGE STATION 188.9

(Drawing 143F089)

The frame at Fuselage Station 188.9 acts as a stiffener for the main fuel cell liner, and the lower cross beam forms the forward web of the wing torsion carry-through box. The lower portion also supports a fitting, which transmits wing chordwise bending loads across the fuselage. The critical conditions are horizontal crash landing and wing support loads in wind tunnel.

CRASH LANDING:

$$p = (214 - 188.9)\,\frac{6.5}{231} \times 8 = 5.65 \text{ psi}$$

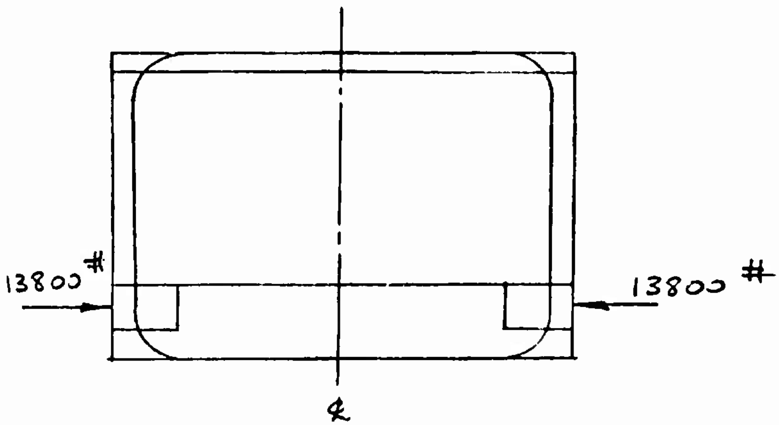
$$w = 5.65 \times 12.35 = 69.8 \ \#/\text{IN.}$$

WIND TUNNEL SUPPORT:

ULT. LOAD @ WING SPT. FTG. (BL 100.75) = 4500#

ULT. LOAD @ LEADING EDGE ATTACH. FTG. =

$$\frac{4500\,(100.75 - 25.25)}{214 - 189.4} = 13800\ \#$$



FRAME FUSELAGE STATION 201.9

(Drawing 143F081)

Frame Fuselage Station 201.9 stiffens the main fuel cell liner. The frame is loaded by internal fuel pressure. Two critical conditions are considered; horizontal crash landing and 6 g maneuver.

CRASH LANDING:

$$\text{ULT. } p = (214 - 201.9)\frac{6.5}{231} \times 8 = 2.72 \text{ psi}$$

$$w = 12.55 \times 2.72 = 34.2 \text{ \#/IN.}$$

6 g MANEUVER:

$$\text{ULT. } p_{MAX} = 28.4 \times \frac{6.5}{231} \times 6 = 4.8 \text{ psi}$$

$$w = 12.55 \times 4.8 = 60.3 \text{ \#/IN.}$$

FUSELAGE BULKHEAD - STATION 214.00

The bulkhead at Fuselage Station 214.00 consists of the fuselage section of the wing forward spar together with a full web framed and stiffened by formed aluminum sections. The bulkhead serves to redistribute fuselage torsion and fuselage and front spar shears between the space frame and the forward fuselage structure; to support the forward engine support frame (Reference Volume II, Section XIII) and as the aft pressure bulkhead to the forward main fuel tank.

A sketch of the bulkhead with applied loads and reactions for two fuselage loading conditions is shown. The loads applied to the bulkhead are determined as follows:

1. Space frame forward reactions. These loads are taken from Section IX of Volume II for the desired condition, and are applied at the longeron-bulkhead intersections. Loads include kick loads developed by axial loading of the angled forward longerons.

2. Wing forward spar loads. These loads are derived from the difference in fuselage shears and bending moments between Station 214.00 forward and Station 214.00 aft in "Structural Design Loads", Report Number 143. The loads have been transposed from the fuselage reference axis to W. L. 100.00 for clarity of presentation.

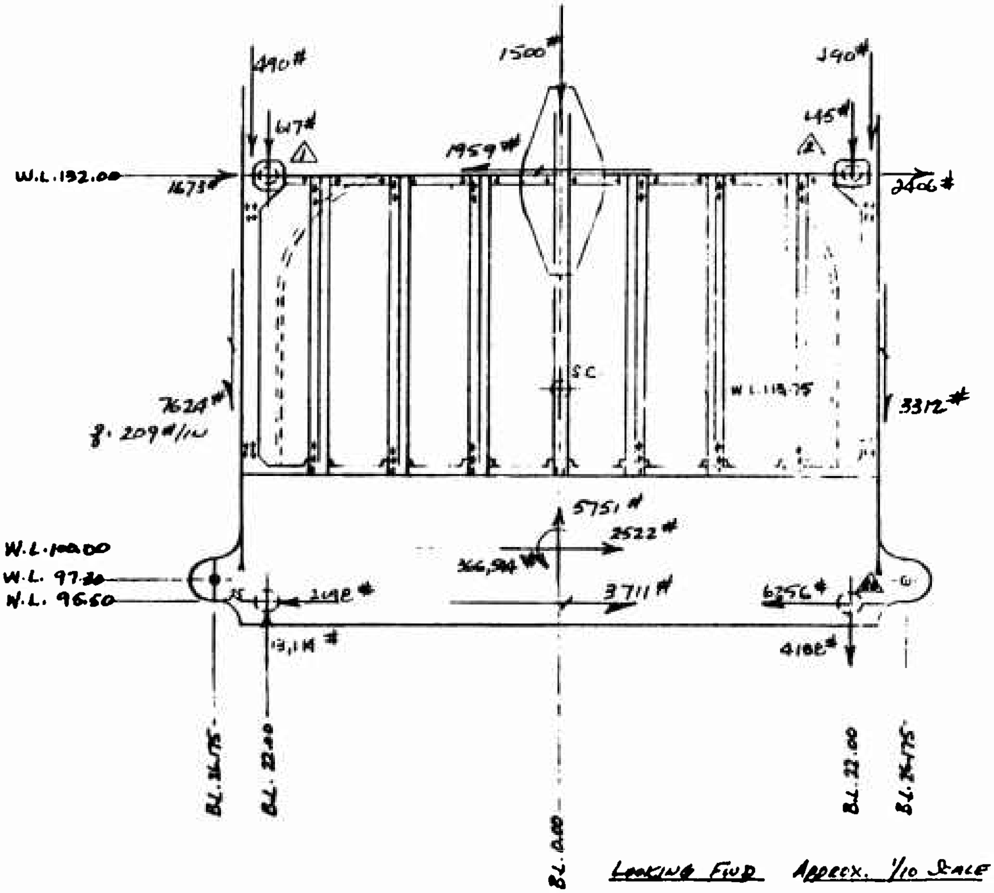
3. Forward engine support loads. These loads are taken from Section VI and distributed to the bulkhead per Section XIII of Volume II.

Reaction shear flows are provided by the forward fuselage torque box bounded by the longerons, and are calculated assuming uniform shear flow to react torque and side load, and vertical load reacted by horizontal and vertical webs respectively.

FUSELAGE BULKHEAD - STATION 214.00

Loading Condition L-10 Rev.

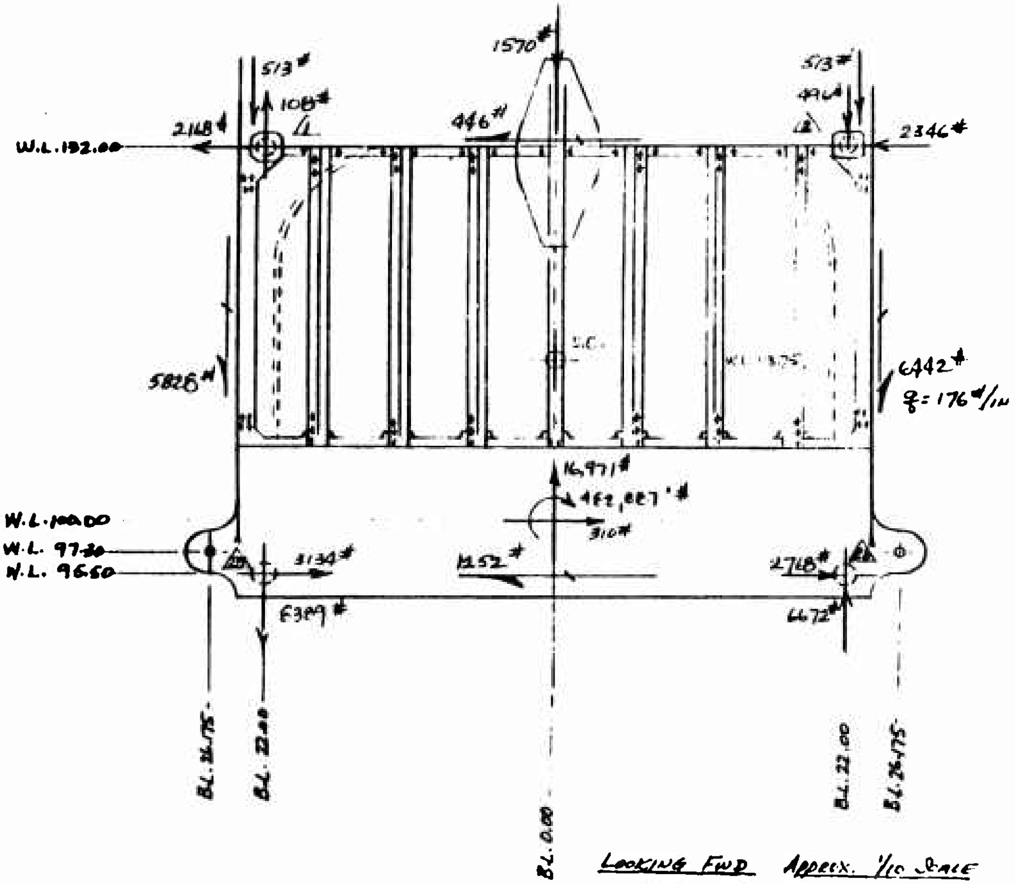
Ultimate Loads



FUSELAGE BULKHEAD - STATION 214.00

Loading Condition Roll 4P Rev.

Ultimate Loads



FUSELAGE BULKHEAD - STATION 214.00

Bulkhead Pressure Loading:

Maximum fuel pressure is exerted on the bulkhead during landing condition L-16, dynamic spring-back condition.

η_x = -2.73 Ult.

η_z = 5.67 Ult.

p = .0281 psi/in./g

p_{η_x} = .0281 (49.00) (2.73) = 3.76 psi uniform pressure

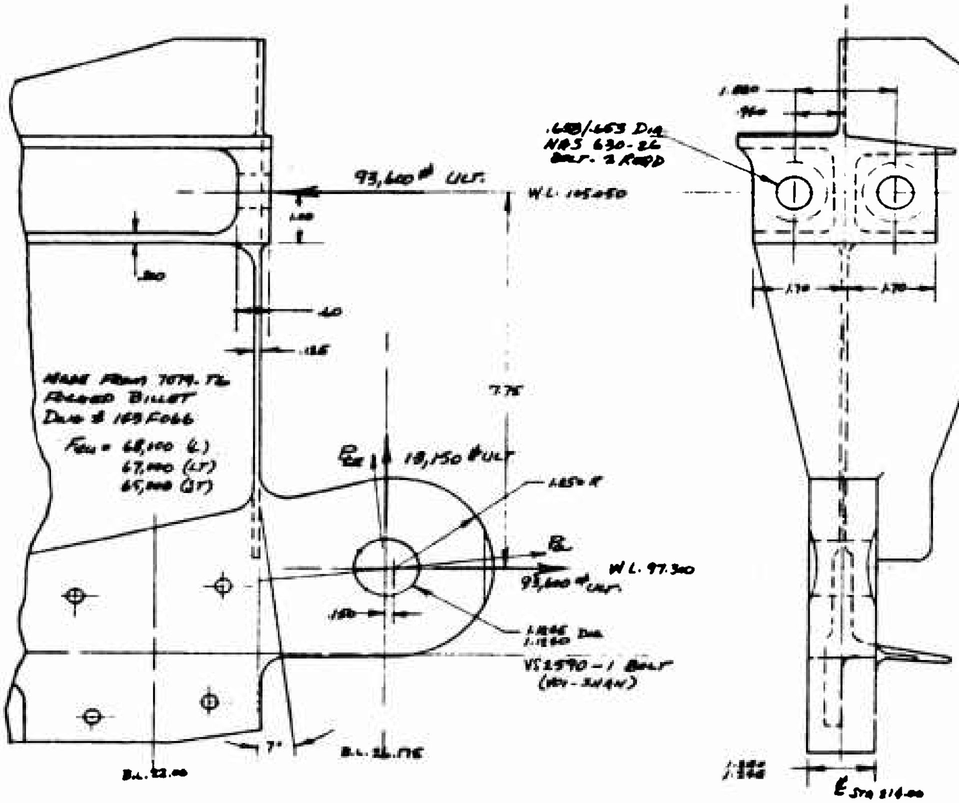
p_{η_z} = .0281 (25.77) (5.67) = 4.11 psi @ spar upper cap - W. L. 106.23

Total maximum fuel pressure on the bulkhead web varies linearly from 3.76 psi at W. L. 132.00 to 7.87 psi at W. L. 106.23.

FUSELAGE BULKHEAD - STATION 214.00

Front Spar Attachment Fitting

Ref. Drawing No. 143F010



FUSELAGE BULKHEAD - STATION 214.00

Front Spar Attachment Fitting

LOWER LUG:

CRITICAL LOADING CONDITION FOR THE ATTACHMENT FITTING LOWER LUG IS SYM COND, PLAFO". [REF. REPORT NO. 63B096 p. 134]

$P_y = 93,600$ #

$P_z = 13,150$ #

THE LUG AXIS OF SYMMETRY IS SEVEN DEGREES FROM A HORIZONTAL REFERENCE PLANE. THEREFORE AXIAL AND TRANSVERSE LOAD COMPONENTS ARE:

$P_a = 93600 \cos 7° + 13150 \sin 7° = 94,505$ #

$P_{tr} = 13150 \cos 7° - 93600 \sin 7° = 1645$ #

LUG ANALYSIS REF: MELCON-HOBLIT METHOD, "PRODUCT ENGINEERING", JUNE 1953, p. 160.

AXIAL LOADING:

$W/D = 3.70/1.1245 = 3.29$ $\quad K_t = .78$ [CURVE 4]

$a/D = 2.00/1.1245 = 1.78$ $\quad K_{br} = 1.44$

$A_t = (3.70 - 1.1245)(1.245) = 3.206 \text{ in}^2$

$A_{br} = 1.1245(1.245) = 1.400 \text{ in}^2$

$P_{tu} = K_t A_t F_{tu} = .78(3.206)(68000) = 170,046$ #

$P_{bru} = K_{br} A_{br} F_{tux} = 1.44(1.400)(67000) = \underline{135,072}$ #

TRANSVERSE LOADING:

$A_1 = A_4 = 1.35(1.245) = 1.681 \text{ in}^2$

$A_2 = A_3 = 1.288(1.245) = 1.604 \text{ in}^2$

$A_{av} = 6 \Big/ \left(\frac{3}{1.681} + \frac{1}{1.604} + \frac{1}{1.604} + \frac{1}{1.681}\right) = 6/3.625 = 1.66$

$A_{av}/A_{br} = 1.66/1.400 = 1.19$ $\quad K_{tru} = 1.20$ [FIG. 17]

$P_{tru} = K_{tru} A_{br} F_{tux} = 1.20(1.400)(67,000) = \underline{112,560}$ #

$R_a = \frac{94,505}{135,072} = .700$ $\quad (.700)^{1.6} = .566$

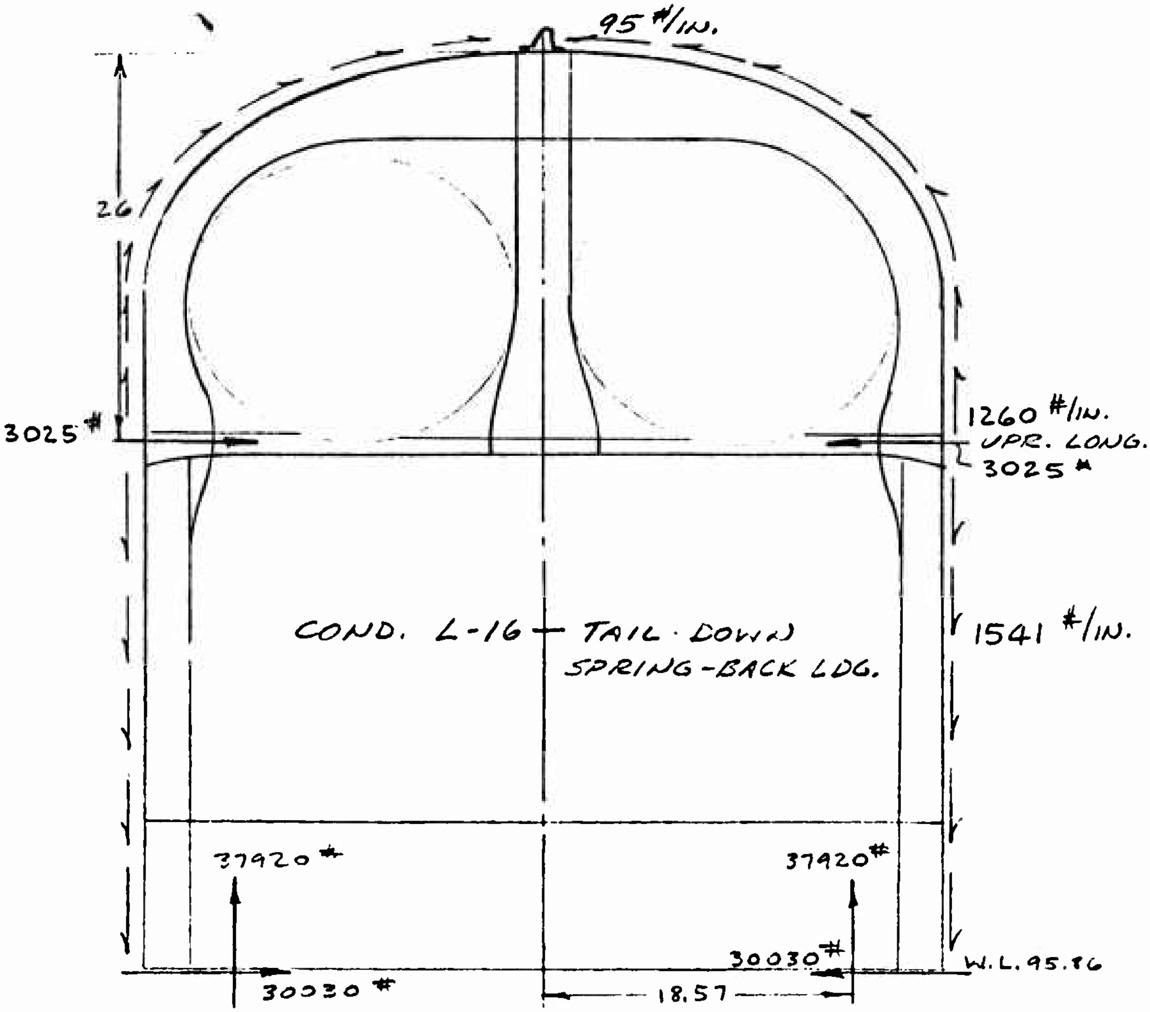
$R_{tr} = \frac{1645}{112,560} = .015$ $\quad (.015)^{1.6} = .0012$

$M.S. = \frac{1}{(.5672)^{.625}} - 1 = \underline{+.42}$

FRAME FUSELAGE STATION 287

(Drawing 143F019)

The frame at Fuselage Station 287 redistributes loads from the center section truss structure to the aft semi-monocoque structure. Secondary loads are applied to the frame by tailpipe and aft fuel cell support fittings. M. L. G. loads are applied to the frame through 143F020 attachment fittings, which also functions as an integral part of the frame.



FRAME FUSELAGE STATION 287

Critical symmetrical condition is L-16 tail-down, spring-back landing.

Loads applied to the M. L. G. attachment fitting by the landing gear and space truss are computed on Page 68 .

Total vertical load/side = 31950 + 18800 - 2 x 6415

= 37920# (applied @ B. L. 18.57)

Total side load/side = 28000 + 1280 + 1570 - 820

= 30030# (applied @ W. L. 95.86)

Loads applied by upper longeron cluster are given in Volume II, Section XI. The longeron is normal to the plane of the frame, and therefore does not apply any in-plane loads. The X brace applies a side load.

Ultimate load (member 9-13) = 1.5 x 3432 = + 5148#

Side component = 5148 x .5883 = 3025#

Distance between longerons = 36

$$\text{Reacting shear flow} = \frac{37920}{36} = 1052 \text{ \#/in.}$$

Curved panel above upper longeron is loaded by shear flow resulting from unloading upper external longeron and effective tensile skins. Total load is determined from bending stresses at Fuselage Station 296.5 given on Page 115 of Volume I.

FRAME FUSELAGE STATION 287

ITEM	w_p	t	A	e	f_t	$P = eAf_t$
LONG.			.224	.08	50552	906
1	1.5	.032	.048	.08	49783	191
2	4.52	↑	.1447	.09	49604	646
3	6.01	│	.1922	.11	48732	1032
4	5.96	│	.191	.13	46400	1150
5	5.99	│	.1918	.17	42119	1377
6	6.04	│	.1932	.23	35711	1588
7	6.02	↓	.1928	.39	28073	2110
8	4.5	.032	.144	1	20383	2940
						11940

DISTANCE BETWEEN FRAMES = 296.5 - 287 = 9.5

MIN. $q = 906/9.5 = 95$ #/IN @ TOP

MAX. $q = 11940/9.5 = 1260$ #/IN @ UPR. LONGERON

ASSUME LINEAR VARIATION BETWEEN ABOVE VALUES.

TOTAL SHEAR /SIDE $= \dfrac{95 + 1260}{2} \times 26 = 17600$ #

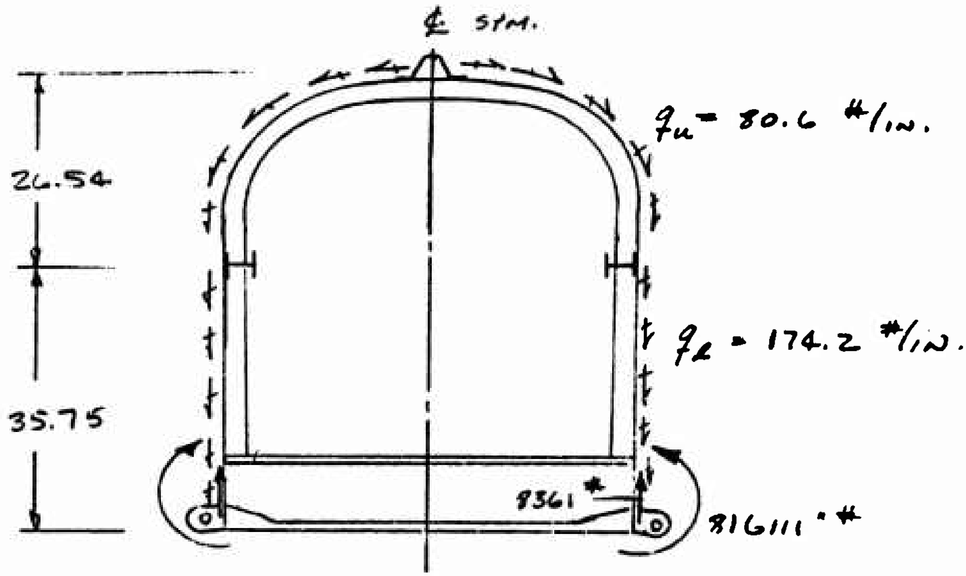
LOWER PANEL $q = 17600/36 = 489$ #/IN.

TOTAL $= 489 + 1052 = 1541$ #/IN.

FRAME FUSELAGE STATION 296.5

(Drawings 143F021 and 143F022)

The frame at Fuselage Station 296.5 distributes the wing rear spar shears and unsymmetrical B. M. (fuselage torsion) to the fuselage box. Wing symmetrical bending moments are carried through the fuselage by the frame lower member, which is a continuation of the wing rear spar. Loads for the critical symmetrical flight condition are shown below (Ref. Wing Stress Analysis, Report No. 130 Page 134).



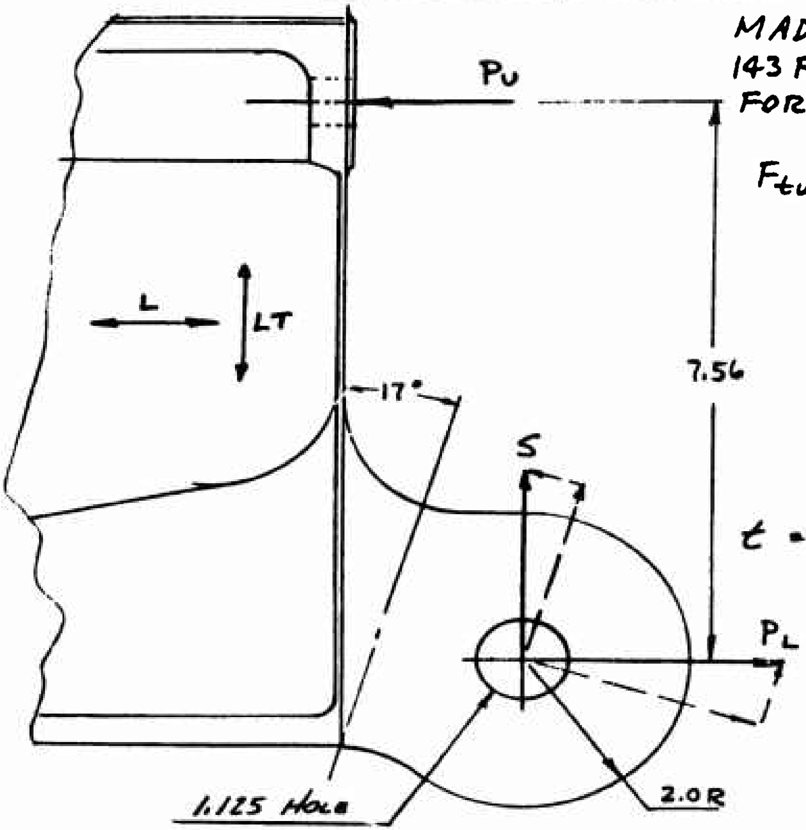
COND. 5-C, SYM. FLIGHT

B.M. = 1.5 × 9.9 × 54957 = 816111 "#

SHEAR = 1.5 × 9.9 × 563 = 9361 #

FRAME FUSELAGE STATION 296.5

Rear Spar Attachment Fitting (143F022)



MADE FROM :
143F067 7079-T6
FORGED BILLET

F_{tu} = 68000 psi (L)
67000 (LT)
65000 (ST)

$S = 8361$ # $P_U = P_L = \frac{816111}{7.56} = 108000$ #

LUG REFERENCE AXIS 17° FROM VERTICAL IS USED TO DETERMINE AXIAL & TRANSVERSE LOAD COMPONENTS.

$P_a = 108000 \cos 17° - 8361 \sin 17° = 101500$ #

$P_{tr} = 8361 \cos 17° + 108000 \sin 17° = 37800$ #

FRAME FUSELAGE STATION 296.5

Rear Spar Attachment Fitting (143F022)

Lug is analyzed by Melcon-Hoblit method from Product Engineering, June 1953, Page 160.

LUG WITHOUT BUSHING:

$W/D = 4/1.125 = 3.56$ $\qquad K_t = .77$ (CURVE 4)

$a/D = 2/1.125 = 1.78$

$D/t = 1.125/1.25 = .9$ $\qquad K_{br} = 1.44$

$A_T = (4 - 1.125)1.25 = 3.594$ $\qquad A_{br} = 1.125 \times 1.25 = 1.408$

$P_{tu} = K_t A_t F_{tu} = .77 \times 3.594 \times 68000 = 185000\#$

$P_{bru} = K_{br} A_{br} F_{tux} = 1.44 \times 1.408 \times 67000 = 136000\#$

$A_1 = A_4 = 1.58 \times 1.25 = 1.975$

$A_2 = A_3 = 1.437 \times 1.25 = 1.796$

$A_{AV} = 6/\left(\frac{3}{1.975} + \frac{2}{1.796} + \frac{1}{1.975}\right) = 1.91$

$A_{AV}/A_{br} = 1.91/1.408 = 1.36$

$K_{tru} = 1.35$ (FROM FIG. 17)

$P_{tru} = K_{tru} A_{br} F_{tux} = 1.35 \times 1.408 \times 67000 = 127000\#$

$R_a^{1.6} + R_{tr}^{1.6} = 1$

$R_a = \frac{101500}{136000} = .745$ $\qquad (.745)^{1.6} = .624$

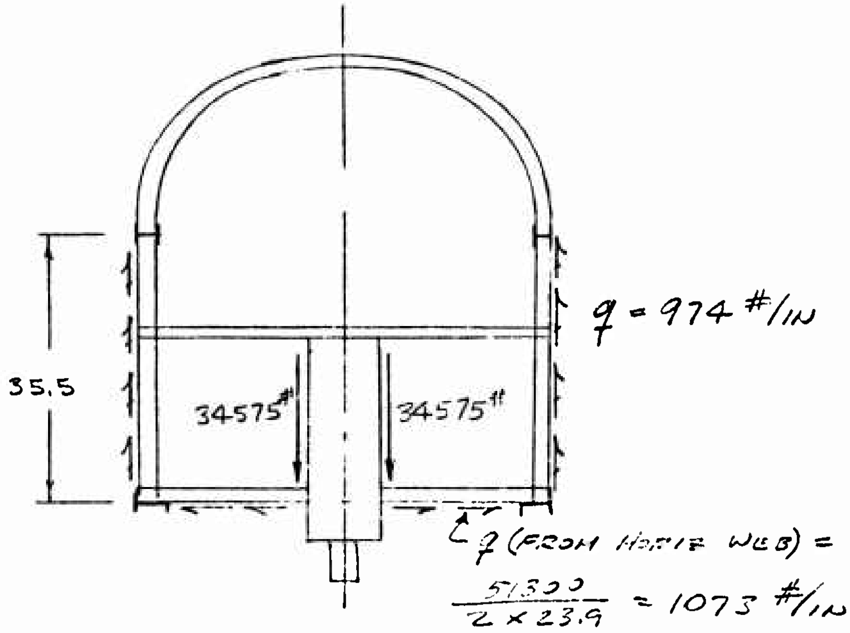
$R_{tr} = \frac{37800}{127000} = .298$ $\qquad (.298)^{1.6} = \frac{.144}{.768}$

$M.S. = \frac{1}{(.768)^{.625}} - 1 = +.04$

BULKHEAD FUSELAGE STATION 316.5

(Drawing 143F025)

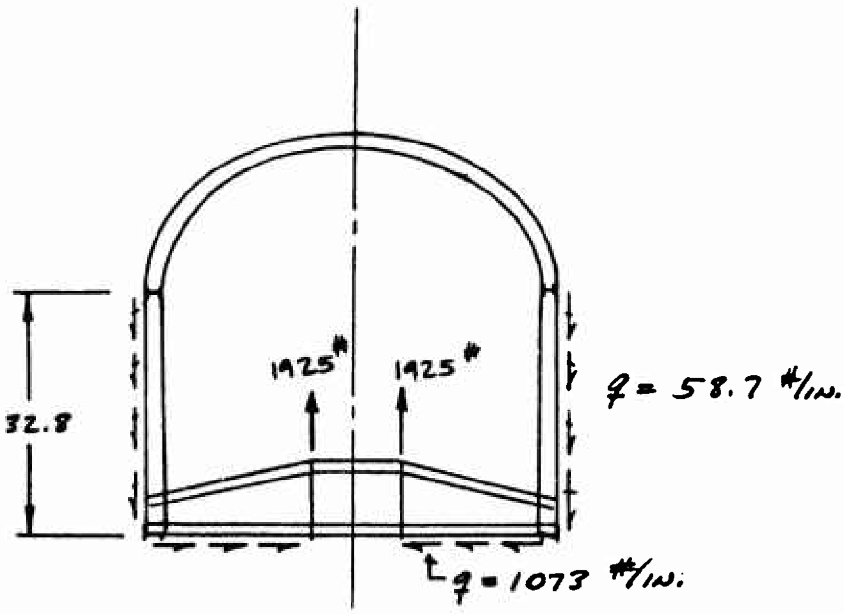
The bulkhead at Fuselage Station 316.5 transfers the vertical component of the drag strut load to the fuselage box. The drag strut load is applied to the bulkhead-through-attachment-fitting 143F118, which is an integral part of the bulkhead. The lower cap of the bulkhead is also loaded axially by shear flow in the lower shear web (143F057), resulting from transfer of the drag strut horizontal component to the longerons. The critical load occurring during tail down, spring-back landing is shown below. It is conservatively assumed that the shear is reacted only by the fuselage skin between the upper and lower longerons. (Ref. fitting analysis, page 75 , for loads.)



BULKHEAD FUSELAGE STATION 341

(Drawing 143F029)

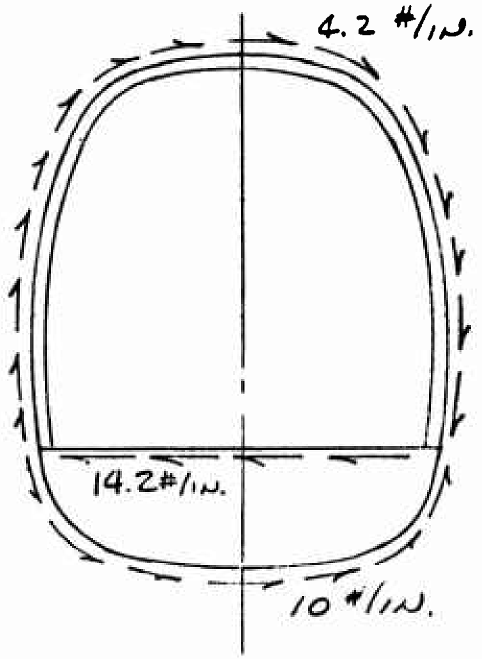
The bulkhead at Fuselage Station 341 supports the aft end of M. L. G. drag strut support structure. Loads applied to the lower member are beamed to the fuselage side skins. The lower cap is also loaded axially by shear flow in the lower shear web, resulting from transfer of the drag strut horizontal component to the longerons. Critical loads for tail down, spring-back condition are shown below. (Ref. Page 75 .)



FRAME FUSELAGE STATION 366

(Drawing 143F033)

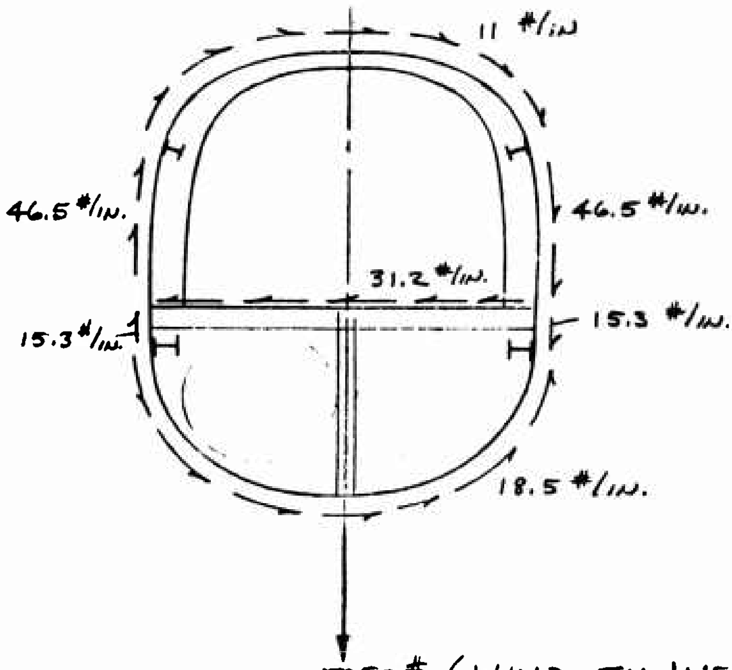
The frame at Fuselage Station 366 redistributes side shear and torque from the full fuselage section aft to the forward section, where the lower skin is replaced with the lower shear web to provide space for the M. L. G. Net frame loading is found by subtracting shear flows on the forward section from those aft. The critical condition is LG-4 Volume I, Pages 147 and 160).



CANTED FRAME FUSELAGE STATION 389.7

(Drawing 143F038)

The lower fuselage skin aft of the canted frame is eliminated by the tail-pipe exit nozzle, and is replaced functionally by a shear web above the tailpipes. The canted frame at Fuselage Station 389.7 redistributes lateral shear and torque between the fore and aft sections. Jacking and hoisting loads are also distributed to the fuselage by this frame. Redistribution shear flows for the critical condition, LG-4, are shown below. Critical load applied by jacking fitting results from supporting the airplane in the wind tunnel (4500# down and 1500# aft).



(WIND TUNNEL SPT. LOAD)
REACTIONS NOT SHOWN
REF. P. 83

VERTICAL STABILIZER ATTACHMENT

The vertical stabilizer is attached to the fuselage by means of three frames which are integral portions of the three spars. The $\frac{Mc}{I}$ distribution of bending moment to the three spars at the root station is altered to allow for possible inaccuracies resulting from the sweep effect. A conservative overlap distribution is assumed. Spar bending moments are computed below from bending stresses computed in Ryan Report No. 132 " EMPENNAGE STRESS ANALYSIS " Page 101. Condition LG-4 is critical. Total shear is distributed in proportion to the spar bending moments.

	B. M.		% Total
Front Spar	- 13.1 x .175 x 23530 =	53800	22.5
Center Spar	- 14 x .462 x 25147 =	162800	68.1
Rear Spar	- 7.6 x .216 x 13651 =	22400	9.4
		239000	

Assume Following Distribution:

		B. M.*	Shear*
Front Spar	25%	66000"#	1325#
Center Spar	75%	198000	3975#
Rear Spar	20%	52800	1060#

*Root B. M. = 264000"#
Root Shear = 5300#

Spar Axial Loads

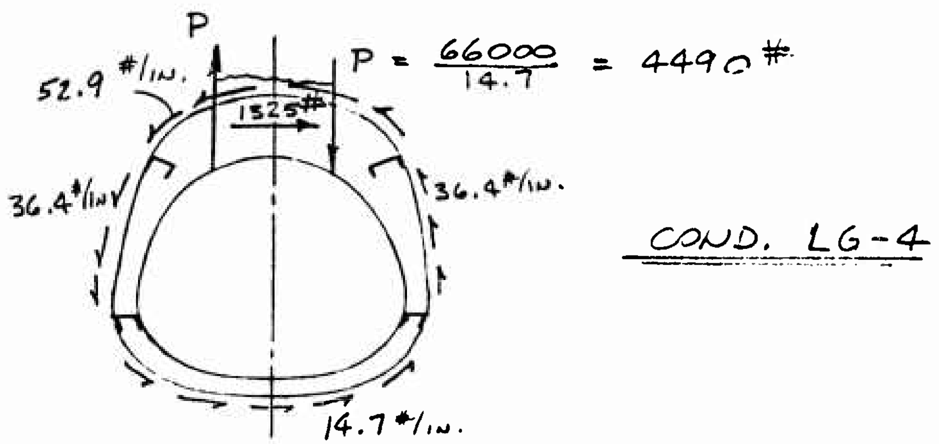
Maximum horizontal stabilizer shear of -10653# (Ref. "Empennage Stress Analysis", Report No. 132, Page 6) is distributed to spars as follows, (critical condition is F-12):

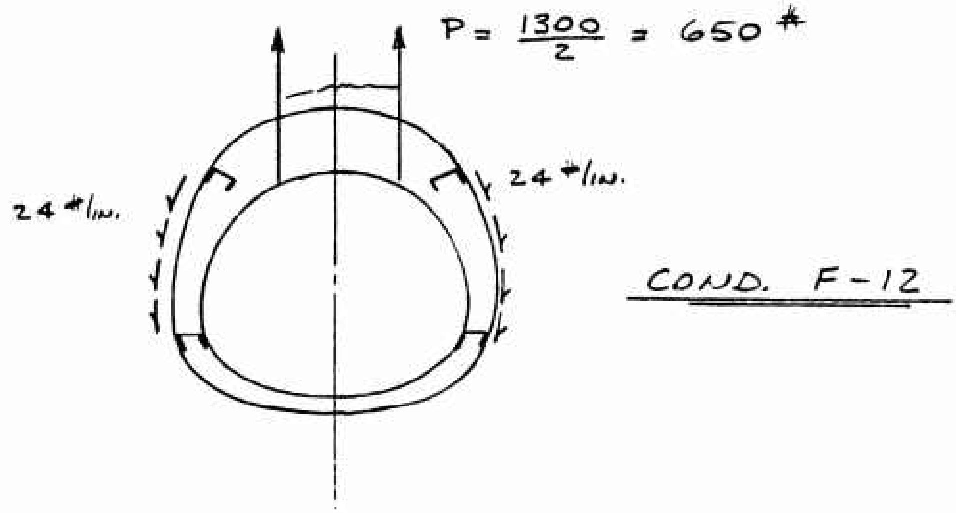
Front Spar	1300#
Center Spar	-6360#
Rear Spar	-5000#

VERTICAL STABILIZER FRONT SPAR FRAME

(Drawing 143T005)

Frame distributes vertical stabilizer loads to fuselage. Two critical loading conditions are shown below.

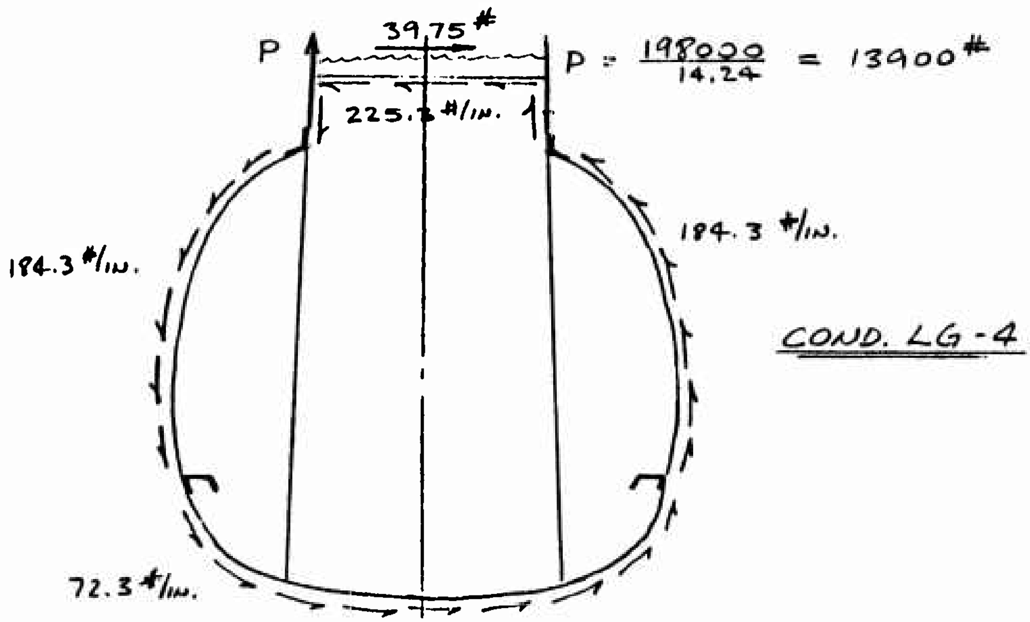


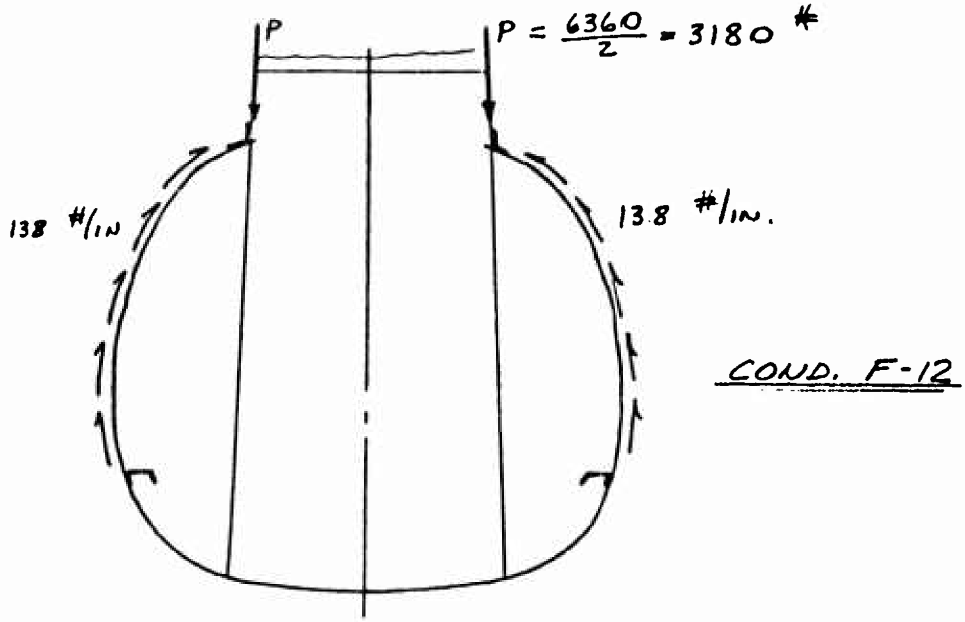


VERTICAL STABILIZER CENTER SPAR BULKHEAD

(Drawing 143T007)

This bulkhead distributes vertical stabilizer loads to the fuselage.

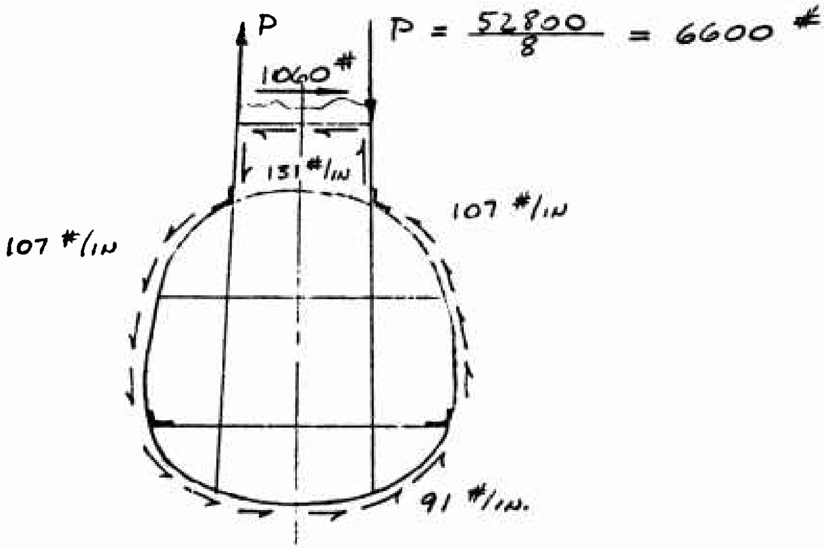


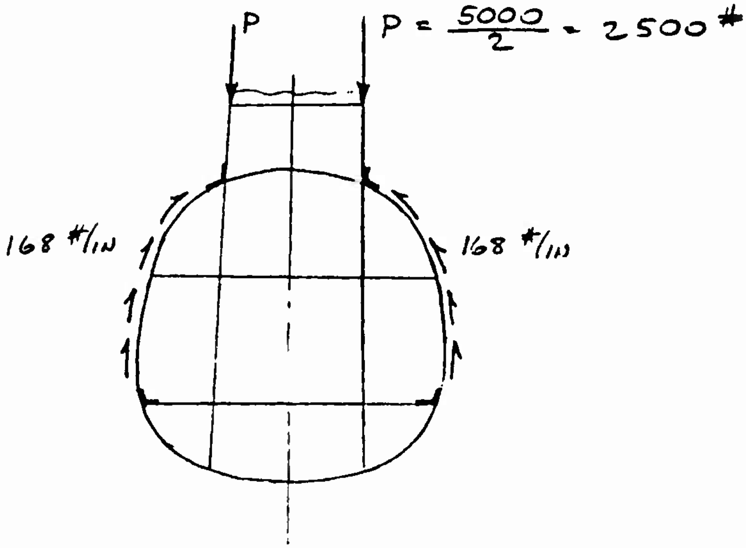


VERTICAL STABILIZER REAR SPAR FRAME

(Drawing 143T009)

The rear spar frame distributes vertical stabilizer loads to the fuselage.



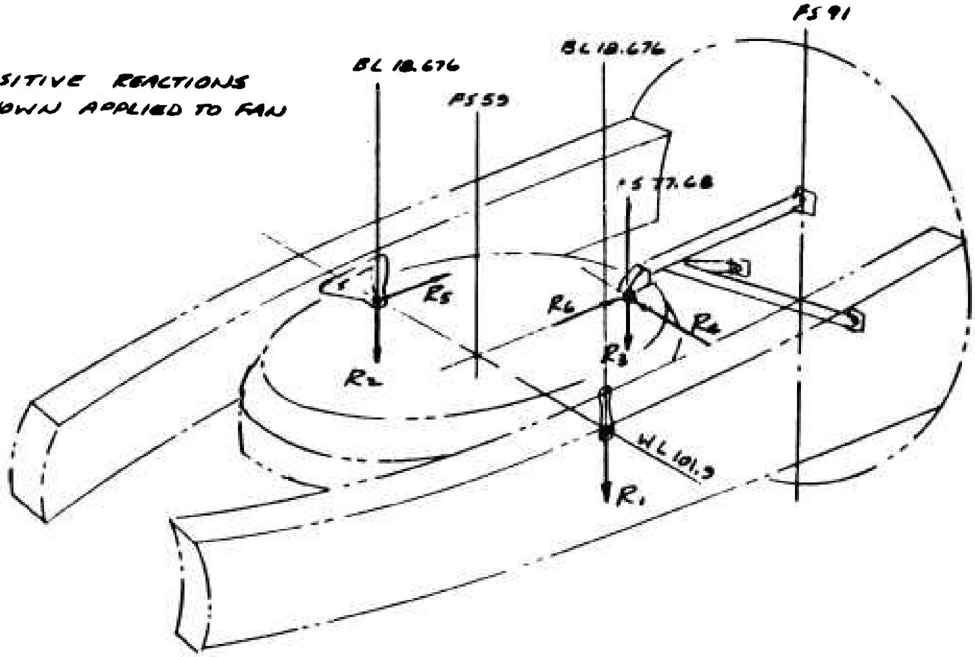


PITCH FAN MOUNTS

The pitch fan is mounted at 3 points; two at the nose side beams and one at the aft tripod which is supported by bulkhead Fuselage Station 91. The left hand side mount reacts only the vertical load and the right side reacts both vertical and longitudinal loads. Loads in all three directions are reacted at the aft mount.

Reacting loads for unit values of applied lift, linear and rotational inertia, and angular velocity are given in the load report. Net reactions are obtained by multiplying unit load values by inertia and velocity factors specified in the design criteria, Report No. 122, and combining these loads to obtain critical conditions.

POSITIVE REACTIONS SHOWN APPLIED TO FAN



PITCH-FAN MOUNTS

PITCH FAN MOUNT LOADS

Basic Data (Ref. G. E. X376 Pitch Fan Specification #113, March 1, 1962)

Weight and C. G.

W = 10 @ Fuselage Station 61.27, B. L. 0 and W. L. 100.15

Moments of Inertia

I_x = 2.646 Slugs -FT^2

I_y = 2.530 Slugs -FT^2

I_z = 5.175 Slugs -FT^2

J = 1.293 Slugs -FT^2 (Polar)

Fan Speed

4684 RPM (Maximum short-time overspeed limit)

4481 RPM (Maximum continuous speed limit)

Fan Lift

T = 1910# (MIL. Power, S. L., 30 kts) (hovering)

T = 2200# (MIL. Power, S. L., 125 kts) (transition)

Critical Conditions

(Ref. Report No. 122, "STRUCTURAL DESIGN CRITERIA" for condition defining parameters.)

Emergency Landing

η_x = -8.0 Ult.

PITCH FAN MOUNT LOADS

CRITICAL CONDITIONS

HOVERING - LIMIT VALUES

FAN LIFT = 1910 # n_z = 0 TO 1.3

$\omega_x = \pm .872$ RAD/SEC. $\dot{\omega}_x = \pm 1.05$ RAD/SEC^2

$\omega_y = \pm 1.00$ RAD/SEC. $\dot{\omega}_y = \pm 1.00$ RAD/SEC^2

$\omega_z = \pm 1.31$ RAD/SEC. $\dot{\omega}_z = \pm 1.05$ RAD/SEC^2

TRANSITION - LIMIT VALUES

FAN LIFT = 2200 # $n_y = \pm .16$ n_z = 1.3 TO 2.0

$\omega_x = \pm 1.38$ RAD/SEC $\omega_x = \pm 2.63$ RAD/SEC^2

$\omega_y = -.610$ RAD/SEC $\dot{\omega}_y = +3.00$ RAD/SEC^2

$\omega_z = \pm 1.31$ RAD/SEC $\dot{\omega}_z = \pm 1.05$ RAD/SEC^2

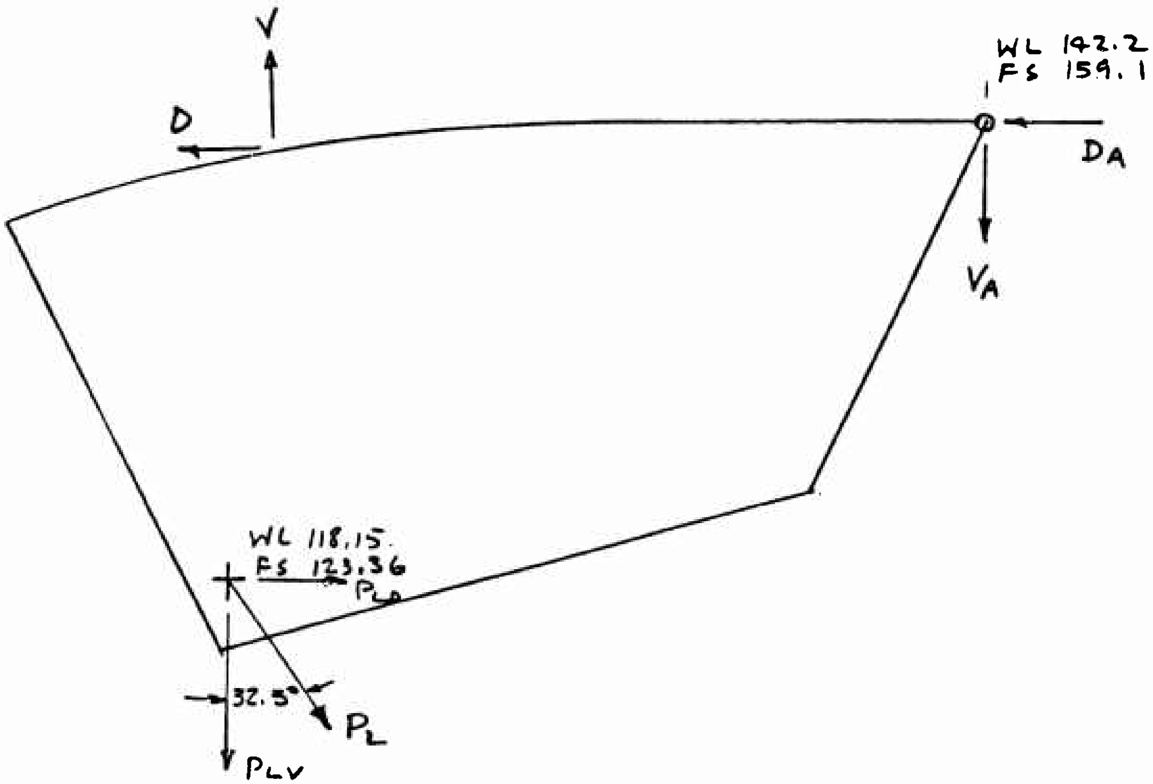
ANGULAR VELOCITIES AND ACCELERATIONS ABOUT A COMMON AXIS ARE PAIRED AND COMBINED WITH LIFT AND LINEAR ACCELERATIONS WHEN CRITICAL TO DERIVE LOAD CONDITIONS.

PITCH FAN MOUNT ULTIMATE LOADS

COND.		LIMIT LOAD PARAMETERS										ULTIMATE REACTIONS (LB)					
		LIFT (LB)	LINEAR LOAD FACTORS			ANGULAR RATES (RAD/SEC)			ANGULAR ACCEL (RAD/SEC²)								
			n_x	n_y	n_z	ω_x	ω_y	ω_z	$\dot{\omega}_x$	$\dot{\omega}_y$	$\dot{\omega}_z$	R_1	R_2	R_3	R_4	R_5	R_6
	1*		-8									39	39	-79	0	0	840
HOVE CNDS	2	1910	-	-	0	-.872	-	-	-1.05	-	-	1196	1196	-274	5	5	-5
	3	1910	-	-	0	.872	-	-	1.05	-	-	659	659	791	-5	-5	5
	4	1910	-	-	0	-	1.0	-	-	-1.0	-	591	1203	242	0	0	77
	5	1910	-	-	0	-	-	1.31	-	-	1.05	928	937	246	-80	-71	71
TRANSITION	6	2200	-	-.16	1.3	-1.38	-	-	-2.63	-	-	1408	1401	-570	12	11	-11
	7	2200	-	0	1.3	1.38	-	-	2.63	-	-	550	553	1113	-12	-11	11
	8	2200	-	0	1.3	-	-.61	-	-	3.0	-	1262	889	302	0	0	0
	9	2200	-	+.16	1.3	-	-	1.31	-	-	1.05	978	990	260	105	-93	93

* COND. 1 IS EMERGENCY LANDING

CANOPY SUPPORT LOADS



Canopy pressures are obtained from Report No. 125, Page 45.

Pad loads 6 through 19 are assumed to be applied symmetrically.

CANOPY SUPPORT LOADS

ULTIMATE LOADS

PAD NO.	LOAD	V ↑	D ←	FS	WL	ΔX	ΔZ	ΔM₁	ΔM₂
6	750	562	145	123	138	36.1	4.2	20300	610
7	700	525	0	130	-	29.1		15250	
8	550	412	0	139	-	20.1		8270	
9	400	300	0	150	-	9.1		2730	
10	790	790	191	121	141	31.1	1.2	28200	170
11	740	790	64	129	142	30.1	.2	22250	10
12	500	500	0	137	-	22.1		11050	
13	300	300	0	148	-	11.1		3330	
14	230	230	0	156	-	3.1		710	
15	790	790	178	121	141	38.1	1.2	30100	210
16	750	750	65	127	142	32.1	.2	24050	10
17	450	450	0	136	-	23.1		10380	
18	350	350	0	145	-	14.1		4930	
19	230	230	0	155	-	4.1		950	
Σ		6879	593					182500	1010

ΣM_1 & ΣM_2 ARE TOTAL MOMENT ABOUT PIVOT DUE TO AIRLOAD.

$$P_{LV} = P_L \cos 32.5° = .843\, P_L$$

$$P_{LD} = P_L \sin 32.5° = .536\, P_L$$

$$P_{LV}\,(\overset{35.74}{159.1 - 123.36}) + P_{LD}\,(\overset{24.05}{142.2 - 118.15}) = 182500 + 1010$$

$$\left.\begin{array}{l} P_L = 4260\ \# \\ P_{LV} = 3600\ \# \\ P_{LD} = 2280\ \# \end{array}\right\}\ \text{ULT / SIDE}$$

CANOPY SUPPORT LOADS

TOTAL PIVOT LOADS:

$$V_A = 2(6880 - 3600) = 6560^{\#}$$

$$D_A = 2(2280 - 590) = 3380^{\#}$$

BOTH SIDES

CRASH LANDING COND.

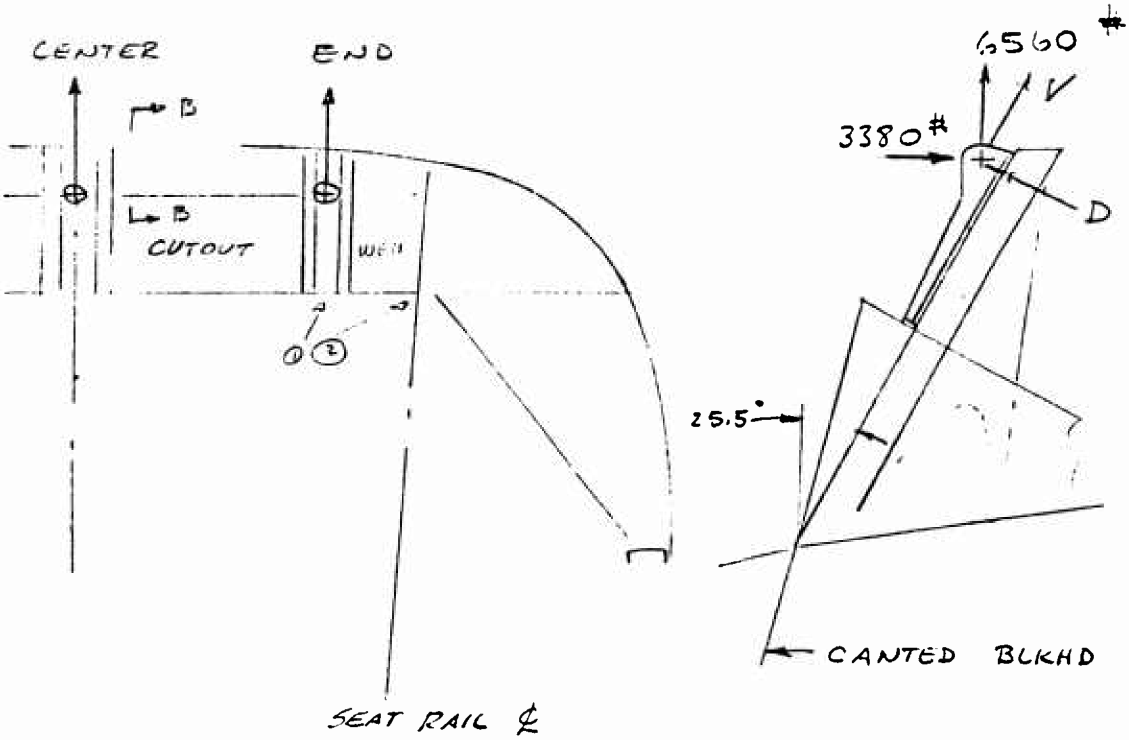
ULT. LOAD FACTOR = 40

WT. = $50^{\#}$

ULT LOAD = $40 \times 50 = 2000^{\#}$

CANOPY SUPPORT LOADS

Distribution to Hinge Fittings



Assume Following Distribution (Conservative Overlap)

.50 Center **.375 Ends**

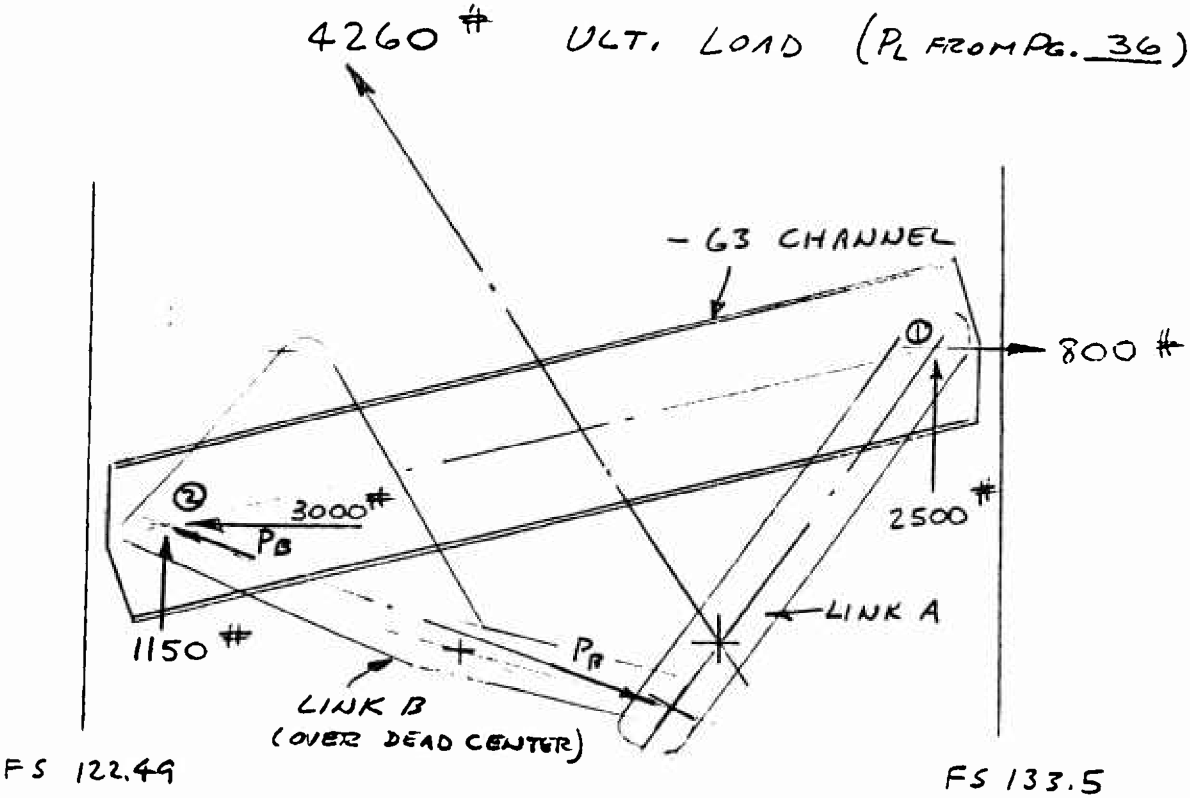
$V = 6560 \cos 25.5° + 3380 \sin 25.5° = 7380\#$

$D = 6560 \sin 25.5° - 3380 \cos 25.5° = 530\#$

Center	Ends
$V_c = 7380 \times .5 = 3690\#$	$V_E = 7380 \times .375 = 2770\#$
$D_c = 530 \times .5 = 265\#$	$D_E = 530 \times .375 = 200\ \#$

CANOPY SUPPORT LOADS

Latch Loads



$\Sigma M_1 = 0$

$4260 \times 4.28 = 5.7\ P_B$

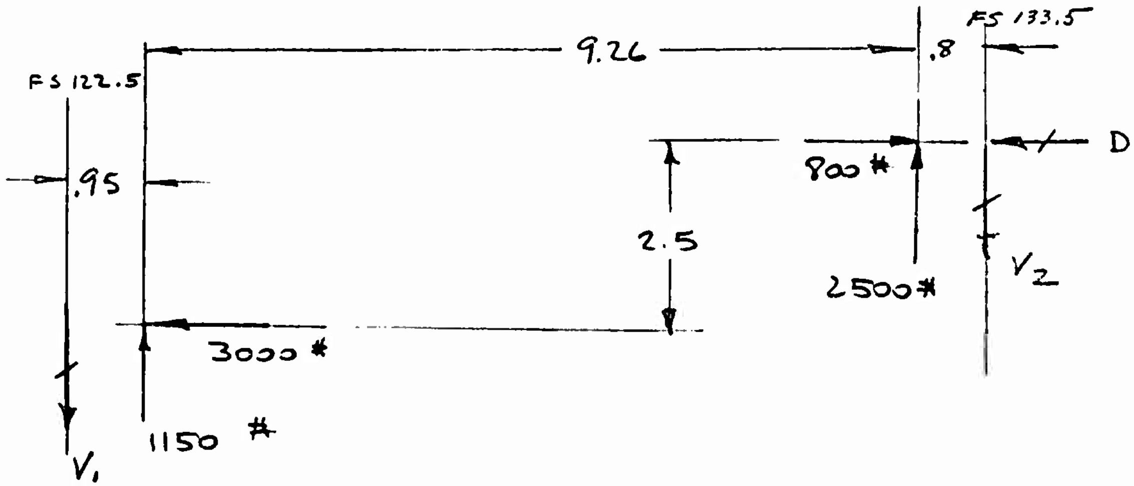
$P_B = 3210\#$

Loads applied to -63 @ points 1 and 2 by graphics shown above as applied to -63 channel.

CANOPY SUPPORT LOADS

Latch Support

Frame Loads



D = -3000 + 800 = -2200# (Reacted aft only)

$11.01\ V_1 = 1150 \times 10.06 + 3000 \times 2.5 + 2500 \times .8$

$V_1 = 1920\#$

$V_2 = 2500 + 1150 - 1920 = 1730\#$

SEAT SUPPORT STRUCTURE

(Drawing 143F006)

The pilot and passenger seats are supported by rails attached to the canted bulkhead at Fuselage Station 145.3. There are provisions for mounting two different types of ejection seats. The structure was first designed to support the North American Aviation, Inc. lightweight seat, and then modified to also accommodate the Douglas Aircraft Co., Escapac I-C seat. Since the seats are interchangeable, loads for both arrangements are given.

Seat ejection and crash landing are the critical conditions.

The NAA seat is attached to the support rail at four fittings. Since the attachment reactions are redundant, a simplifying assumption is used that only two of the supports are active. Loads are then computed for all combinations of two reactions.

The Douglas escape seat is supported by two tracks through a set of three rollers. It is assumed that the normal reactions on the lower pair of rollers are equal.

SEAT SUPPORT STRUCTURE

(NAA Seat)

ULT. LOADS

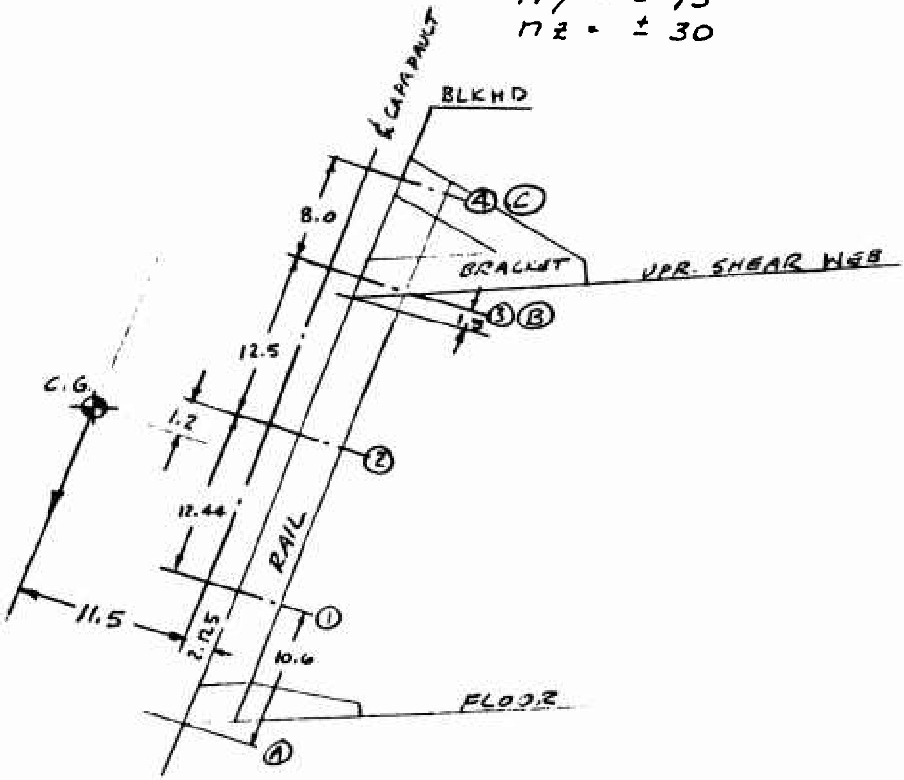
SEAT EJECTION — 30g — WT. = 331.7 #

CRASH LANDING

$n_x = \pm 40$

$n_y = \pm 15$

$n_z = \pm 30$



SEAT SUPPORTED BY 4 FTGS. (PTS. 1, 2, 3 & 4)

RAIL SUPPORTED @ FLOOR & UPPER BRACKET (A, B, C)

SEAT SUPPORT STRUCTURE

(NAA Seat)

Calculation of Rail Bending Moments

COND. 1 – EJECTION

CATAPAULT THRUST REACTED BY SPT. 4 ONLY

UNBALANCED MOMENT ON SEAT = 11.5 T

$T = 30 \times 331.7 = 9940^{\#}$ USE $10000^{\#}$

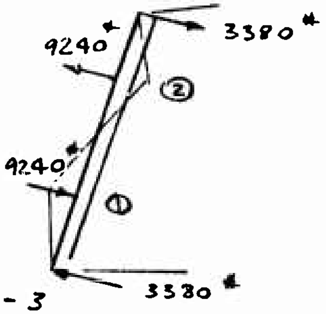
$M = 11.5 \times 10000 = 115000''^{\#}$

CASE A — ASSUME M REACTED BY SPTS. 1 & 2

COUPLE $= \dfrac{115000}{12.44} = 9240^{\#}$

REACTIONS $= \dfrac{115000}{34.04} = 3380^{\#}$

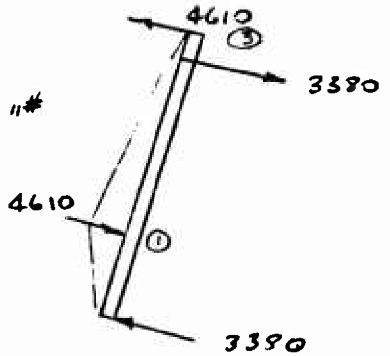
MAX B.M. $= 3380 \times 11 = 37200''^{\#}$



CASE B – M REACTED BY SPTS. 1 - 3

COUPLE $= \dfrac{115000}{24.94} = 4610^{\#}$

MAX B.M. $= 3380 \times 10.6 = 35800''^{\#}$



SEAT SUPPORT STRUCTURE

(NAA Seat)

Rail Bending

CASE C - M REACTED BY SPTS. 1-4

COUPLE = 115000/32.94 = 3490 #

REACTIONS = 115000/43.54 = 2640 #

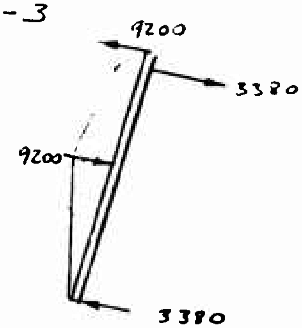
NOT CRITICAL

CASE D - M REACTED BY SPTS. 2-3

COUPLE = 115000/12.5 = 9200 #

REACTIONS = 115000/34.04 = 3380 #

MAX B.M. = 3380 × 23.04 = 78000 "#



CASE E - M REACTED BY SPTS 2-4

NOT CRITICAL

CASE F - M REACTED BY SPTS 3-4

COUPLE = 115000/8 = 14380 #

RAIL SUPPORTED BY UPPER BRACKET — NO BENDING

SUMMARY:

MAX. FTG. LOAD = 14380 #

MAX. REACTION = 3380 #

MAX. RAIL B.M. = 78000 "#

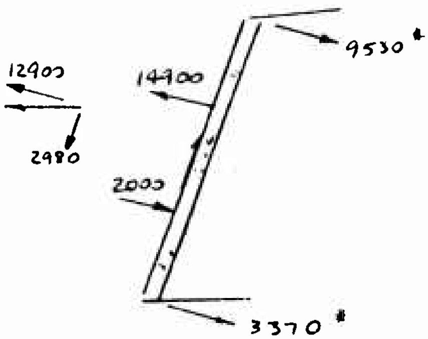
SEAT SUPPORT STRUCTURE

(NAA Seat)

Loads and Rail B. M. for Crash Landing

$P_x = \pm 40 \times 331.7 = 13250^{\#}$

ASSUME SEAT SUPPORTED BY 1 & 2



$13250 \sin 13^\circ = 2980^{\#}$

$13250 \cos 13^\circ = 12900^{\#}$

$P_2 = \dfrac{12900 \times 11.24}{12.44} + \dfrac{2980 \times 13.63}{12.44} = 14900^{\#}$

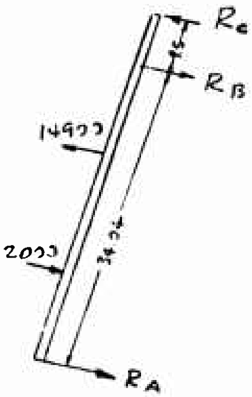
$P_1 = 12900 - 14900 = -2000^{\#}$

$R_U = \dfrac{12900 \times 21.39}{34.04} + \dfrac{2980 \times 13.63}{34.04} = 9530^{\#}$

$R_L = 12900 - 9530 = 3370^{\#}$

MAX. B.M. $= 9530 \times 11 = 104800\ ''^{\#}$

CONSIDER RAIL ALSO SUPPORTED BY BRACKET



$$2 M_B (L_1 + L_2) = \frac{W_1 A_1}{L_1}(L_1^2 - A_1^2) + \frac{W_2 A_2}{L_1}(L_1^2 - A_2^2)$$

$$2 M_B (34.04 + 9.5) = -\frac{2000 \times 10.6}{34.04}(34.04^2 - 10.6^2) + \frac{14900 \times 23.04}{34.04}(34.04^2 - 23.04^2)$$

$$87.08\, M_B = -651000 + 6340000$$

$$M_B = 65400\ ''^{\#}$$

$$R_C = \frac{65400}{9.5} = 6900^{\#}$$

$$14900 \times 11 - 2000 \times 23.44 - 34.04 R_A = 65400$$

$$R_A = 1520^{\#}$$

SEAT SUPPORT STRUCTURE

(NAA Seat)

Seat Support - Crash Landing

$$R_B = 14900 + 6900 - 2000 - 1520 = 18280^{\#}$$

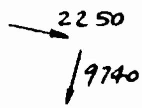
$$\text{MAX B.M.} = 6900 \times 20.5 - 18280 \times 11 = -59800\,{}^{\prime\#}$$

VERTICAL LOAD FACTOR

$$P_R = 30 \times 331.7 = 10000^{\#}$$

$$10000 \sin 13^\circ = 2250^{\#}$$

$$10000 \cos 13^\circ = 9740^{\#}$$

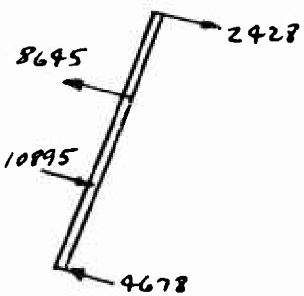


$$P_2 = -\frac{2250 \times 11.24}{12.44} + \frac{9740 \times 13.63}{12.44} = 8645^{\#}$$

$$P_1 = 8645 + 2250 = -10895^{\#}$$

$$R_U = -\frac{2250 \times 21.84}{34.04} + \frac{9740 \times 13.63}{34.04} = 2428^{\#}$$

$$R_L = 2428 + 2250 = -4678^{\#}$$



$$\text{MAX B.M.} = 4678 \times 10.6 = 49600\,{}^{\prime\#}$$

SEAT SUPPORT STRUCTURE
(NAA Seat)

SIDE LOAD = $15 \times 331.7 = 4960^{\#}$

TORQUE = $4960\,(11.5 + 2.125) = 67700''^{\#}$

ASSUME EQUAL REACTIONS AT FITTINGS 1, 2 & 3

SIDE LOAD / FTG. = $4960/3 = 1660^{\#}$

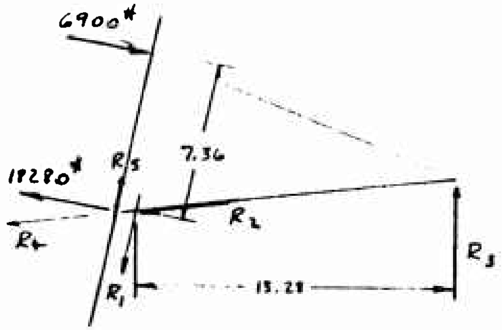
TORQUE / FTG = $67700/3 = 22600''^{\#}$

SEAT SUPPORT STRUCTURE

(NAA Seat)

Upper Support Bracket Loads

Horizontal Crash Landing Condition



$$R_3 = 6900 \times \frac{7.36}{13.28} = 3830^{\#}$$

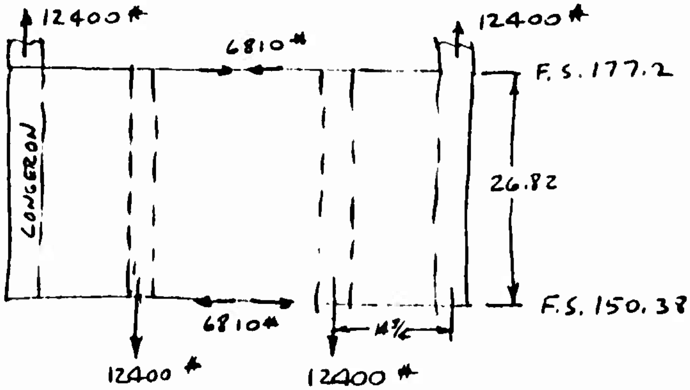
$$\left.\begin{array}{l} R_1 = 1000^{\#} \\ R_2 = 7400^{\#} \end{array}\right\} \text{BY GRAPHICS}$$

$R_4 = 19800^{\#}$ "

$R_5 = 7620^{\#}$ "

NET LOAD ALONG FLOOR = 19800 − 7400 = 12400#

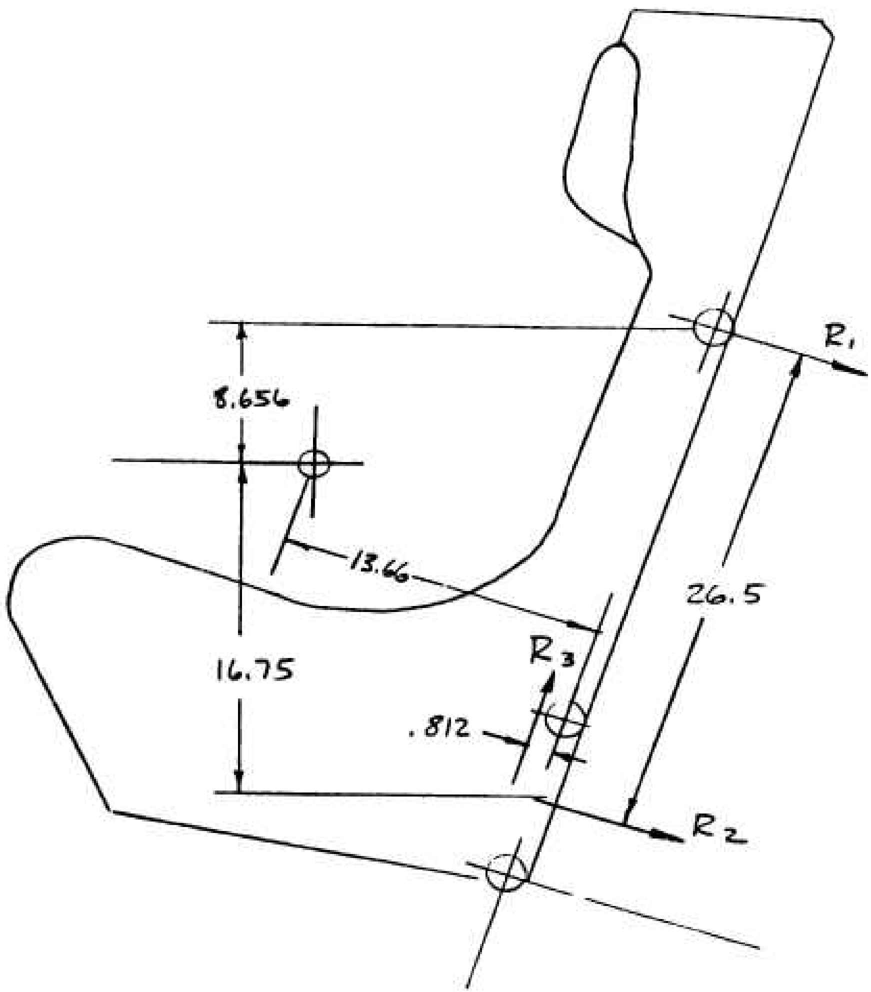
BRACKET UNLOADS ALONG FLOOR TO FRAME FS 177.2



$$q = 12400/26.82 = 462 \ ^{\#}/in.$$

LATERAL STIFFENER LOAD = $462 \times 14.75 = 6810^{\#}$

DOUGLAS I-C SEAT SUPPORT



DOUGLAS I-C SEAT SUPPORT

WEIGHTS	INSTALLED	EJECTABLE
SEAT	50 #	50
ROCKET LAUNCH TUBE	6.25	0
ROCKET	21.75	21.75
PARACHUTE	25.0	25.00
SEAT PAN	5.0	8.0
SEAT ADJ. ACT.	4.5	0
GUIDE RAILS	8.0	0
	123.5	104.75
CREWMAN	201.0	201.0
CLOTHING	12	12
TORSO SUIT	3.5	3.5
	339.5 #	321.25

EJECTION THRUST = 4900×1.5 = 7350# ULT
(INITIAL PEAK)

CRASH CONDITIONS – ULT.

$n_x = \pm 40$

$n_z = \pm 20$ (LIMITED BY ENERGY ABSORBER)
DESIGN CRITERIA SPECIFIES 30

$n_y = \pm 15$

SEAT CANTED 13°

REF. DOUGLAS SPEC 7777126 & LOAD ANALYSIS REPORT FOR OTHER DATA

DOUGLAS I-C SEAT SUPPORT

COND. 1 – 40 g HORIZ. CRASH

$$F_x = 40 \times 339.5 = 13580\#$$

NORMAL COMP. $= 13580 \cos 13° = 13200\#$

PARALLEL " $= 13580 \sin 13° = 3050\#$

$$R_1 = \frac{13580 \times 16.75}{26.5} - \frac{3050 \times .812}{26.5} = 8500\#$$

$$R_2 = \frac{13580 \times 9.656}{26.5} + \frac{3050 \times .812}{26.5} = 4534\#$$

$$R_3 = 3050\#$$

COND 2 – 20 g VERT. CRASH

$$F_z = 20 \times 339.5 = 6790\#$$

NORMAL COMP. $= 6790 \sin 13° = 1528\#$

PARALLEL " $= 6790 \cos 13° = 6600\#$

$$R_1 = \frac{6790 \times 7.23}{26.5} - \frac{6600 \times .812}{26.5} = 1778\#$$

$$R_2 = \frac{6790 \times 15.45}{26.5} - \frac{6600 \times .812}{26.5} = 3758\#$$

$$R_3 = 6600\#$$

DOUGLAS I-C SEAT SUPPORT

COND 3 - EJECTION

$7350^{\#}$ THRUST $\quad$ $321.25^{\#}$ WT.

$n = 7350/321.25 = 22.9$

$R_1 = -R_2 = \frac{7350 \times 13.[illegible]}{9} =$ [illegible] $= 10500^{\#}$

$R_3 = 7350^{\#}$

COND 4 – 15 g SIDE CRASH

$F_y = 15 \times 339.5 = 5090^{\#}$

COUPLE $= 5090 \times 13.66 = 69600''^{\#}$

RAILS 17" APART

LOAD / RAIL $= 69600/17 = 4100^{\#}$

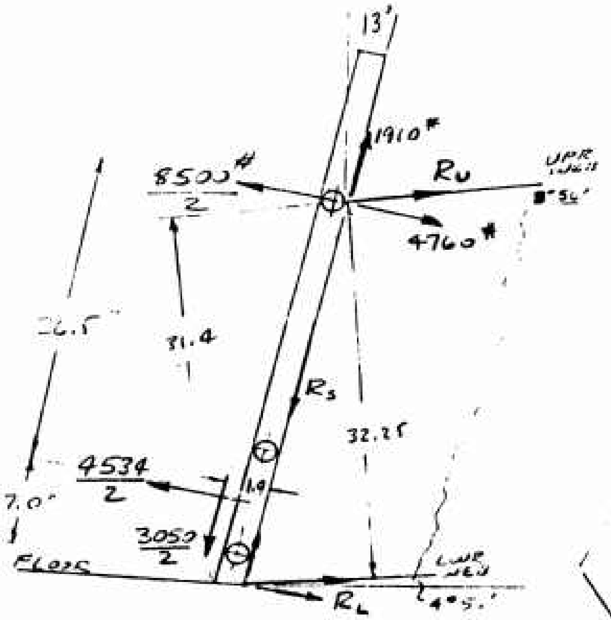
LOAD / RAIL IN COND 1 $= 13580/2 = 6790^{\#}$

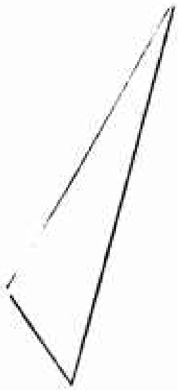
∴ COND. 4 NOT CRITICAL COMPARED TO COND. 1

DOUGLAS I-C SEAT SUPPORT

SUPPORT RAIL LOADS

COND. 1





MAX B.M. =
1690 × 7 = 11800 "#

$$R_U = \frac{1}{31.4}(4250 \times 33.5 + 2267 \times 7 + 1525 \times 1.9)$$

$$R_U = 5120\ \#$$

$$R_L = \frac{1}{32.25}(2267 \times 26.5 - 1525 \times 1.9)$$

$$R_L = 1772\ \#$$

$5120 \cos 21°56' = 4760\#$ $\quad$ $5120 \sin 21°56' = 1910\#$

$1772 \cos 17°5' = 1690\#$ $\quad$ $1772 \sin 17°56' = 545\#$

$$R_S = 1690 + 545 - 1525 = 930\ \#$$

DOUGLAS I-C SEAT SUPPORT

SUPPORT PAN LOADS

COND. 3 - EJECTION

$$\text{COUPLE} = 10500 \times \frac{1}{2} \times 9 = 47200 \text{ "\#}$$

$$R_U = 47200/31.4 = 1505 \text{ \#}$$

$$R_L = 47200/32.25 = 1462 \text{ \#}$$

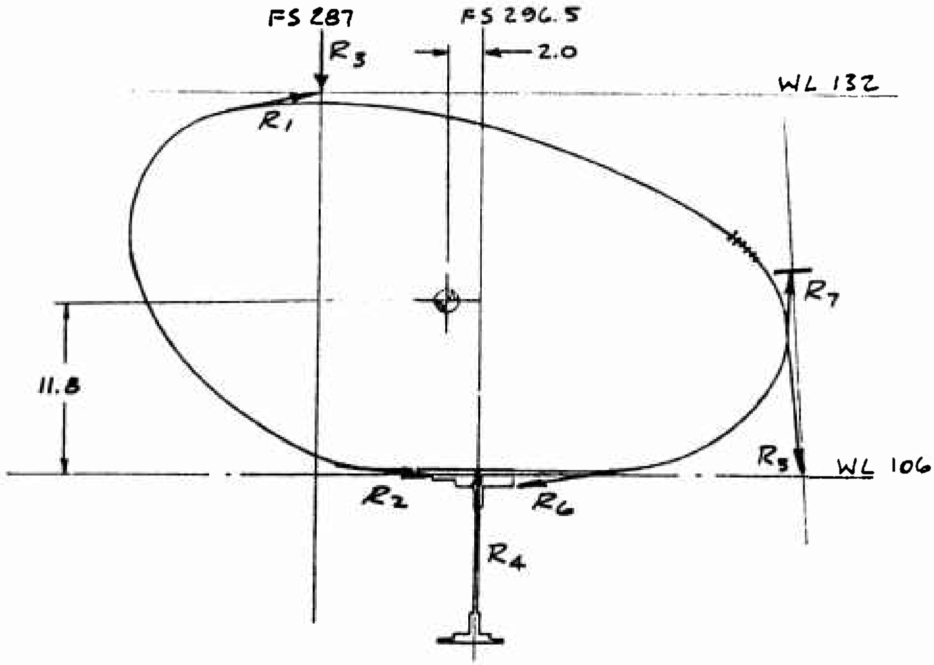
COND. 2 - VERT. CRASH

$$R_L = \frac{1}{32.25}\left(\frac{3758}{2} \times 26.5 + \frac{6600}{2} \times 1.9\right)$$

$$= 1740 \text{ \#}$$

AFT MAIN FUEL TANK

The aft main fuel tank is a separate structure supported by the fuselage as shown by the following sketch:



R_1 & R_2 : TENSION STRAP NOT ATTACHED TO TANK

R_6 & R_7 : TENSION STRAP NOT ATTACHED TO TANK

R_5 : TENSION STRAP ATTACHED TO TANK

R_3 & R_4 : BUMPER REACTIONS, COMPRESSION ONLY

WEIGHT OF TANK & CONTENTS = 900#

AFT MAIN FUEL TANK

Four critical conditions are considered: maximum ± longitudinal load factor and maximum ± vertical load factor. Reacting loads are shown for these conditions on the following pages.

COND. A - FORWARD LOAD

n_x = -8.0 EMERGENCY LANDING

R_1, R_2, R_6, R_7 & R_3 ARE ACTIVE

COND. B - DOWN LOAD

n_z = 6.0 POSITIVE MANEUVER

R_4, R_5, R_6 & R_7 ARE ACTIVE

COND. C - UP LOAD

n_z = -3.0 NEGATIVE MANEUVER

R_3, R_6, R_7 & R_5 ARE ACTIVE

COND D - AFT LOAD

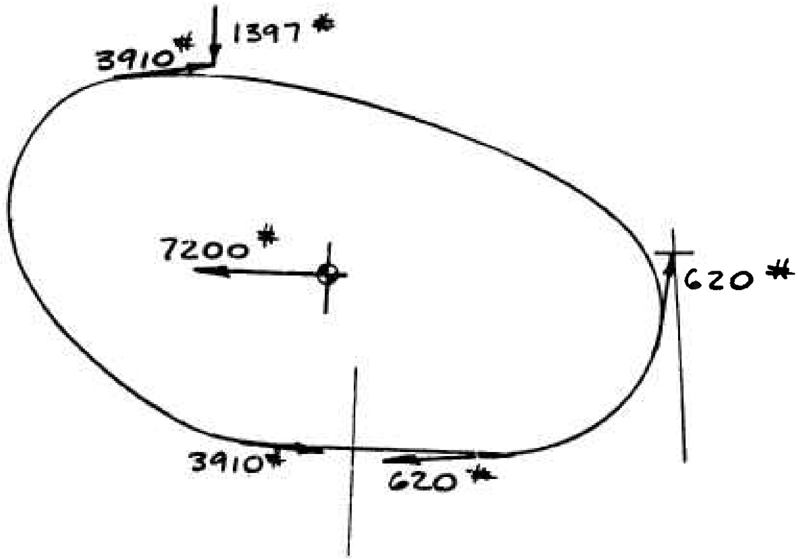
n_x = 1.5 EMERGENCY LANDING

R_6, R_7, R_3 & R_5 ARE ACTIVE

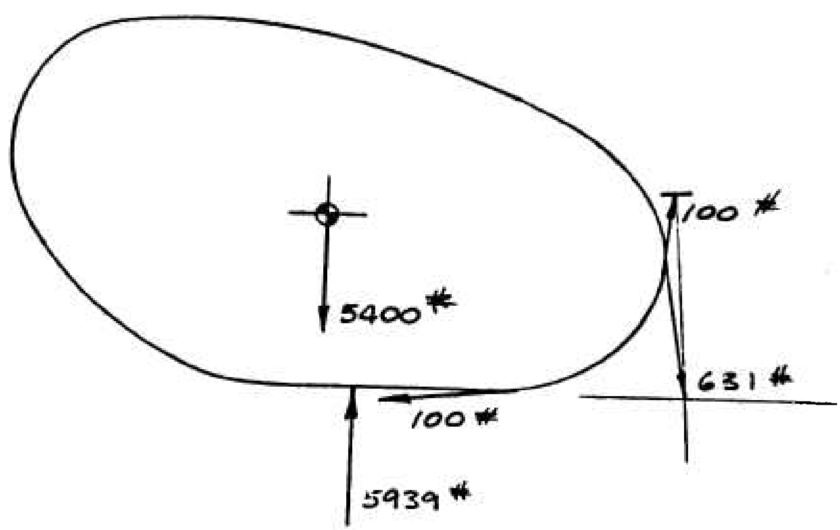
FRICTION OF STRAPS NOT ATTACHED TO TANK IS NEGLECTED.

AFT MAIN FUEL TANK

COND A – FWD. LOAD

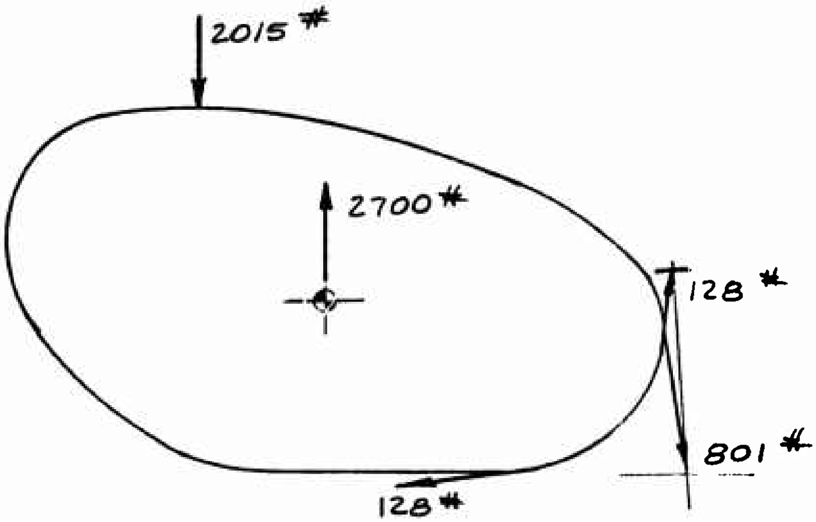


COND B – DOWN LOAD

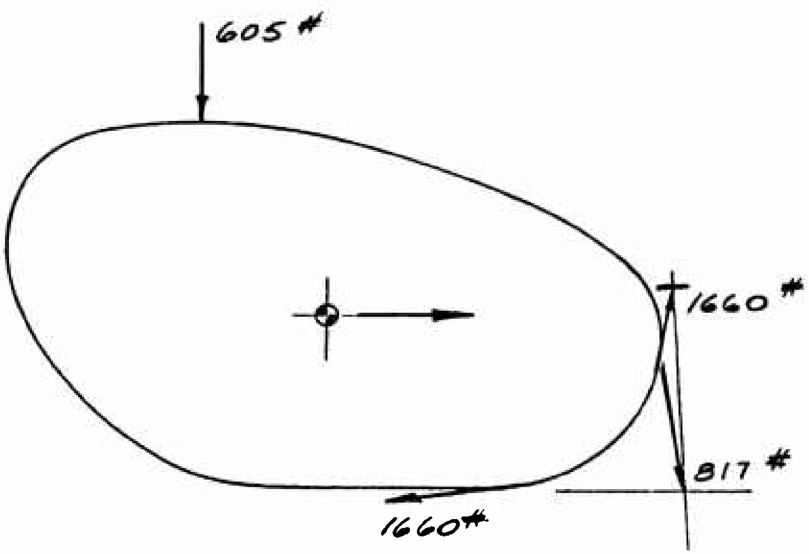


AFT MAIN FUEL TANK

COND C - UP LOAD



COND D - AFT LOAD



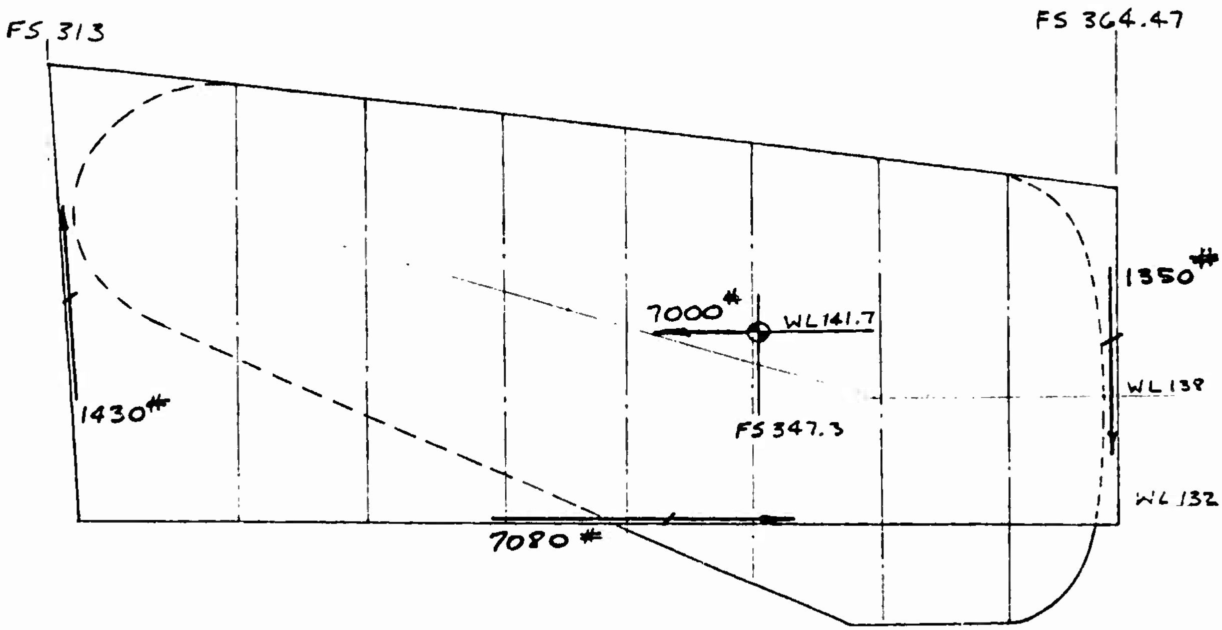
DORSAL FUEL TANK

(Drawing 143F085)

The dorsal tank is an integral part of the upper fuselage access door. Door loads are shown below for emergency landing condition.

Weight of door, tank and fuel = 875#

Maximum forward load = 8 x 875 = 7000# (Ult)



MAX. PRESSURE (AT FWD. END) = $\frac{6.5}{231} \times 49 \times 8$ = 11 psi (ULT)

THRUST SPOILER

(Drawing 143P069)

The thrust spoilers consist of a pair of doors located aft of the tailpipe nozzles and supported by the fairing structure below the fuselage box structure. The tailpipe exhaust impinges on the doors when they are extended. The doors are operated by a single hydraulic actuator located on the airplane centerline. The actuator drives a rod which is connected to the door links. Longitudinal movement of rod and door links joint causes the doors to pivot about the door hinges located at the forward end. The rod/door links joint motion is guided by a track. An idler link at the actuator/rod joint reacts vertical loads so that the guide track is not loaded.

The spoilers are designed for operation under the following condition:

100 kts., hot day, 2500 ft., 9200# G.W. full flaps, 98.6% RPM

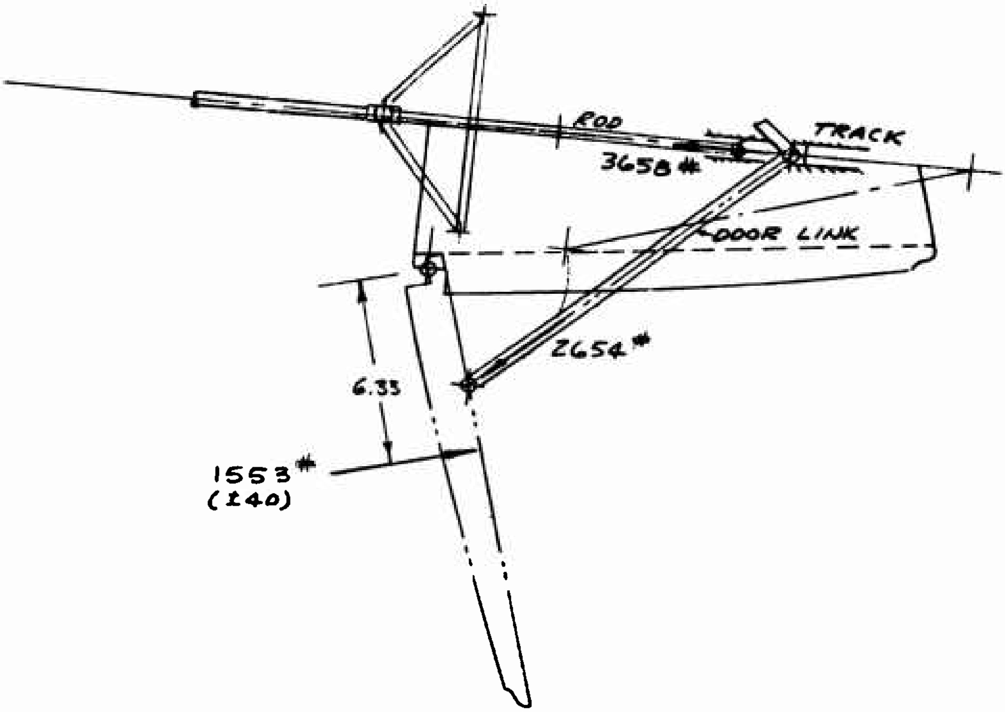
Ultimate load per spoiler = 1553#

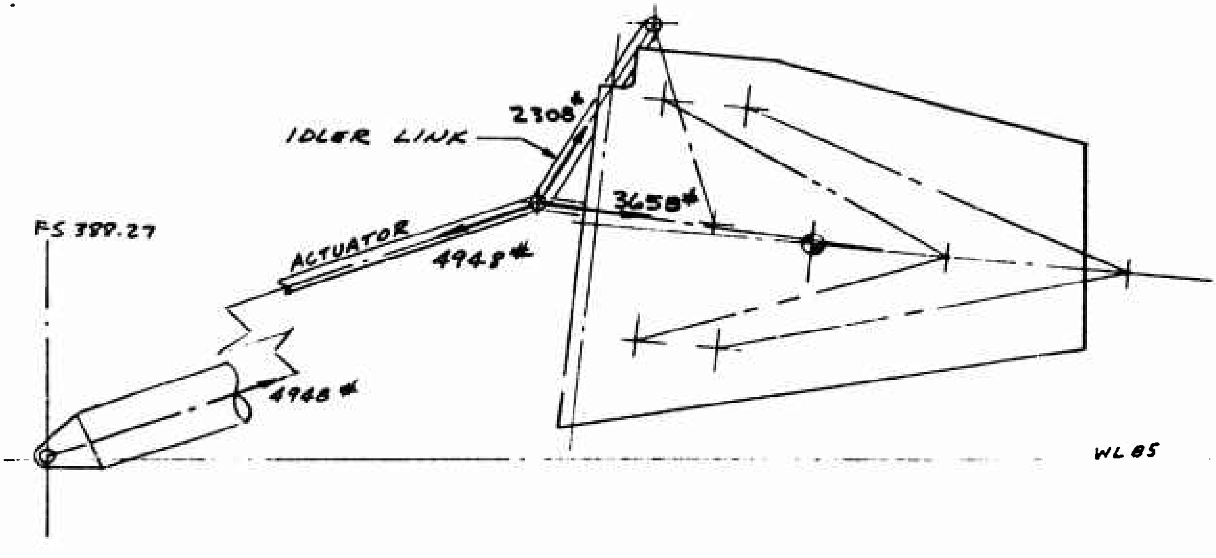
Load is normal to the deflected plane and c.p. is at the center of area.

Unsymmetrical loading due to differential engine RPM of ± 0.5% is ± 40#

Design temperature = 1200° F.

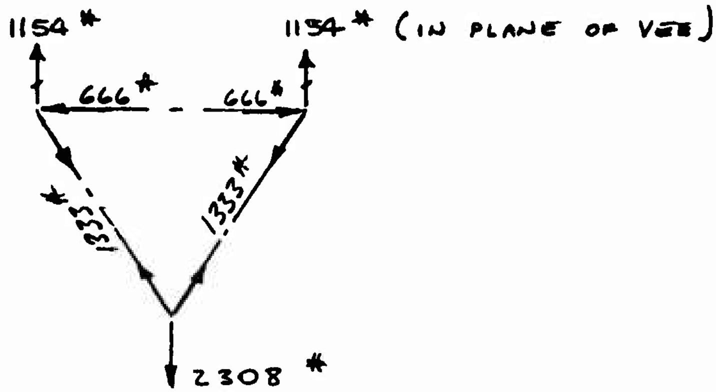
THRUST SPOILER



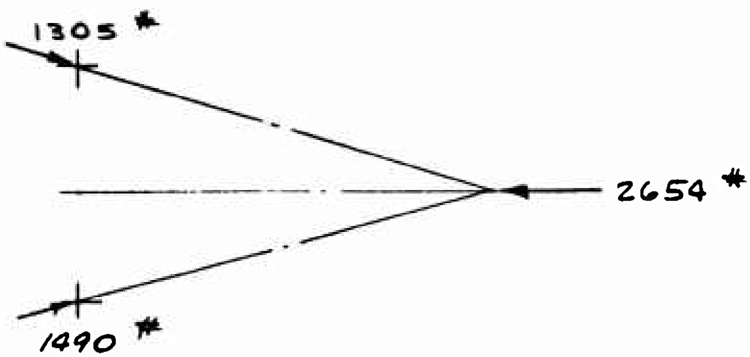


THRUST SPOILER

IDLER LINK FREE-BODY

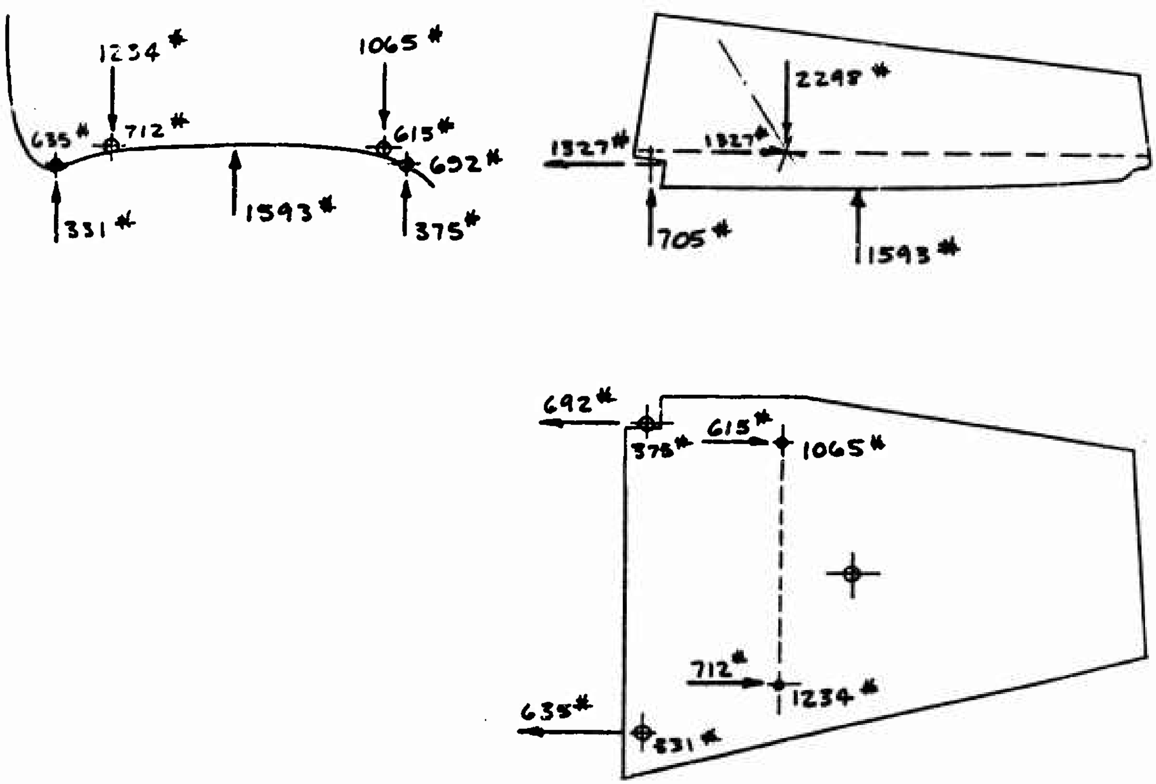


DOOR LINK FREE-BODY



THRUST SPOILER

DOOR FREE - BODY



UPPER LONGERON SPLICE FITTING FUSELAGE STATION 214

(Drawings 143F121 and 143F122)

The upper longeron at Fuselage Station 214 is spliced to the space frame longeron pad by two bathtub type fittings. The longeron load is determined in Volume II. The maximum load occurs in lateral gust condition LG-3.

Ultimate load = 19197# (Ref. Volume II, Section XI)

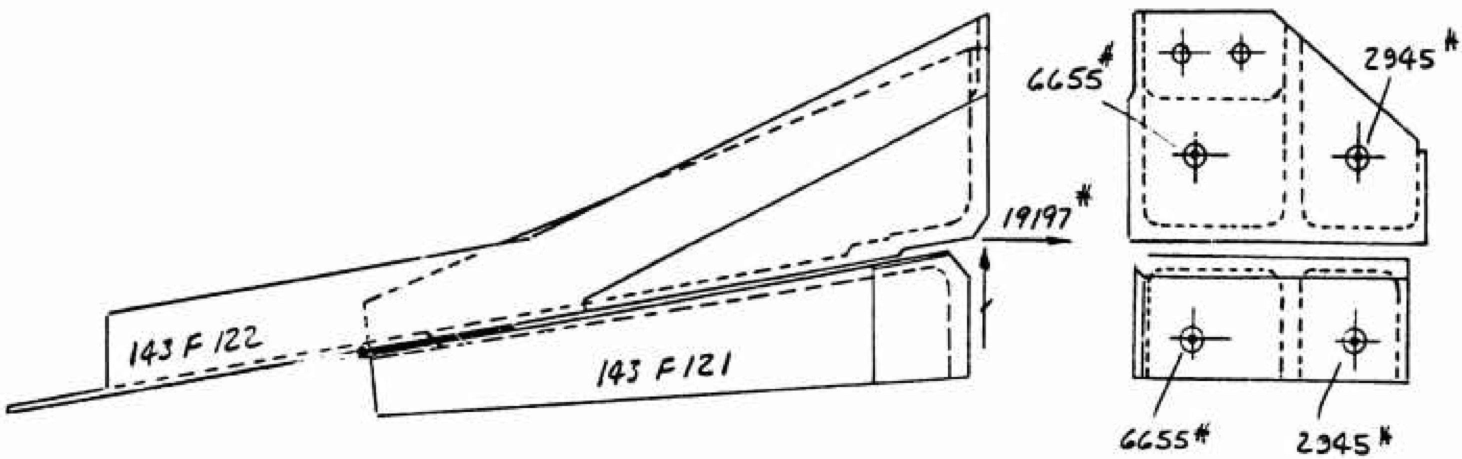
Additional side and vertical loads in the plane of the bulkhead are reacted by Fuselage Station 214 bulkhead. The distribution of load to the four tension bolts is based on the following assumptions:

1. The load is equally distributed to the upper and lower fittings.

2. The distribution to the inboard and outboard bolts is midway between an equal distribution, and one which beams the loads from the longeron centerline (no lateral bending of longitude).

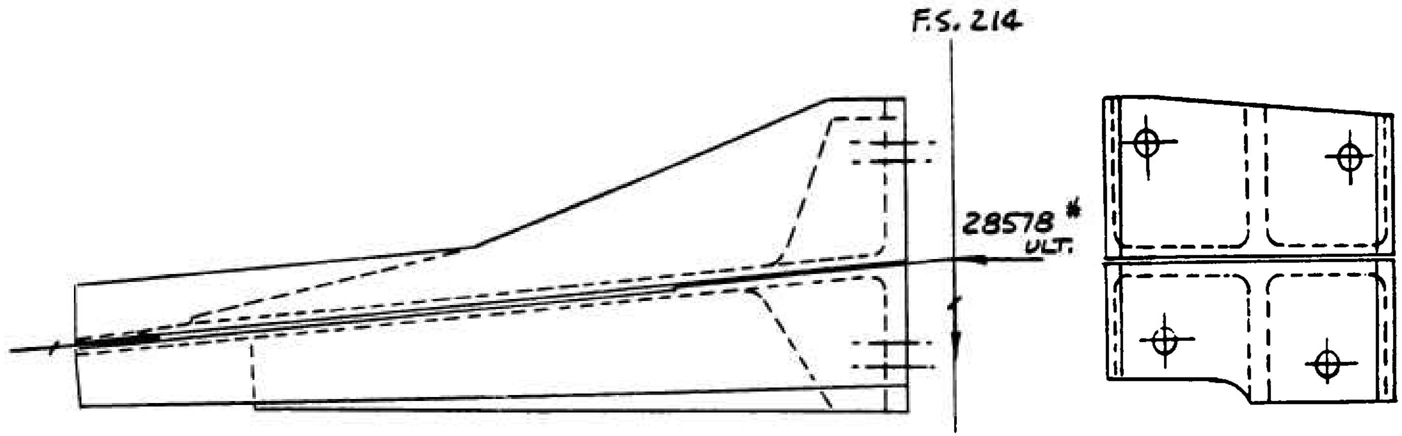
Load per fitting = 19197/2 = 9599#

	Outboard Bolt	Inboard Bolt
Equal distribution	4800#	4800#
Beamed distribution	8510	1089
	2 | 13310	2 | 5889
Assumed distribution	6655#	2945#



UPPER LONGERON SPLICE FITTINGS FS 214

MAT'L 7075-T6 BAR



LOWER LONGERON SPLICE FITTING FS 214

MAT'L 7075-T6 BAR

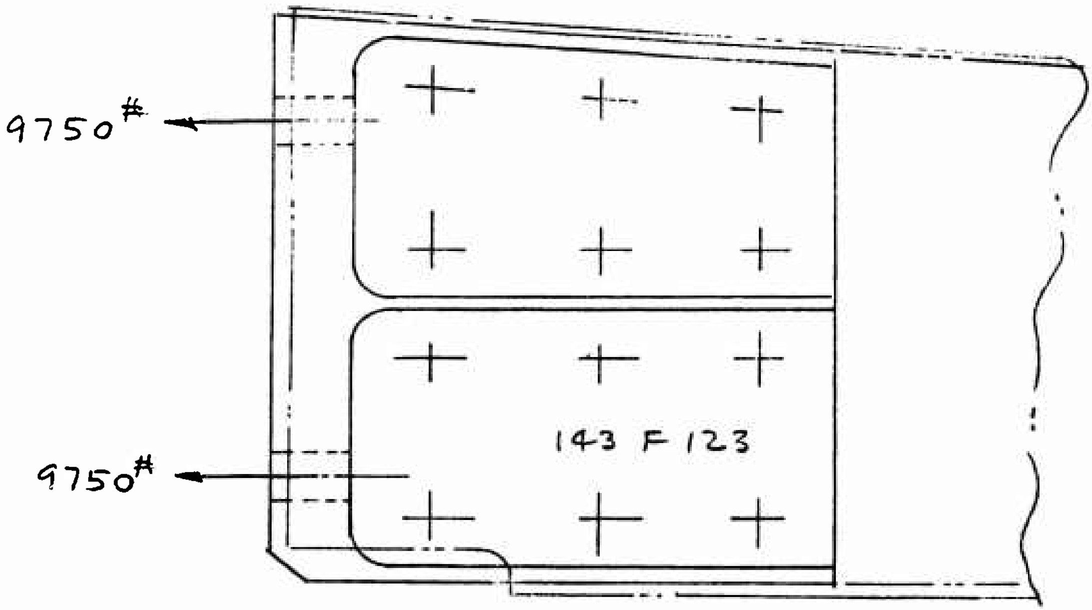
MAX. COMPRESSIVE LOAD = 28578 # (REF. REPT. No. 63B131, SECT. VI)

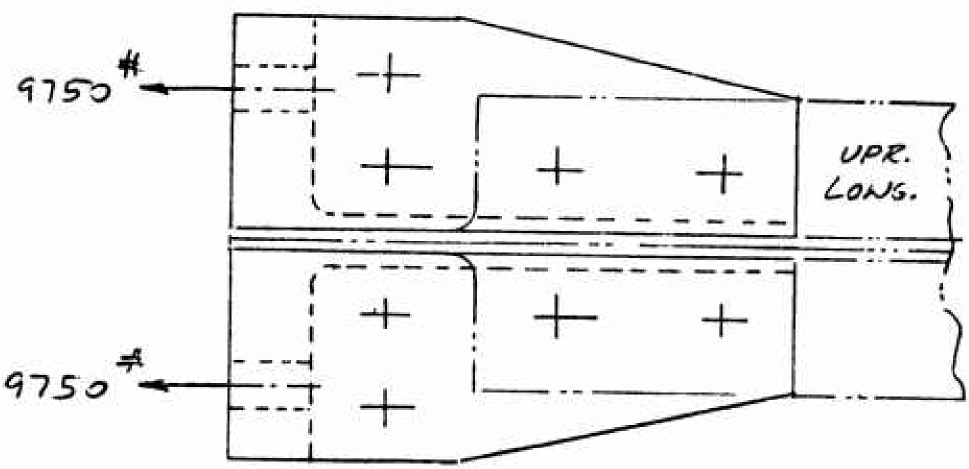
LATERAL GUST COND. LG-3 IS CRITICAL

UPPER LONGERON SPLICE FITTING-FUSELAGE STATION 287

Critical Load = 39000# (Ref. Report No. 63B131, Section XI)

L-16 is critical condition



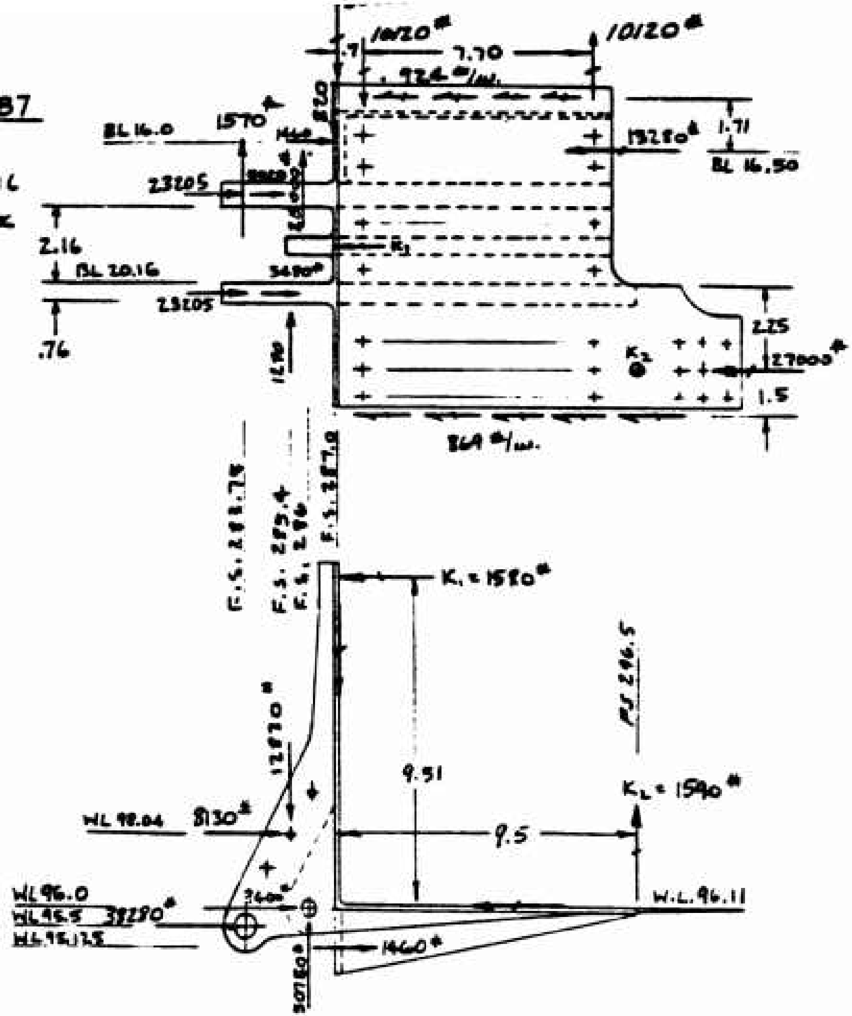


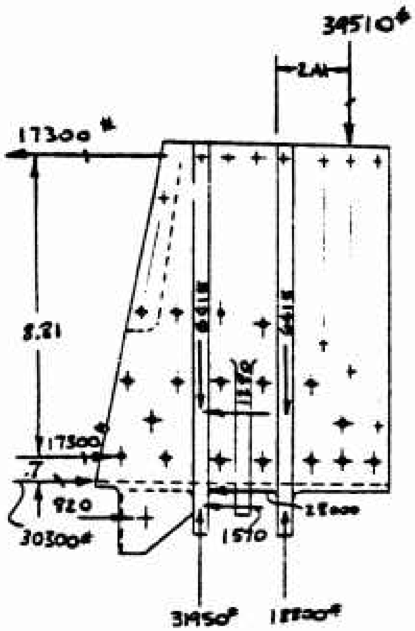
MLG SPT. FTG. STA. 287

DWG. 143 F020

ULT. LOADS FOR COND. L-16

TAIL-DOWN SPRING-BACK





MAIN LANDING GEAR SUPPORT FITTING STATION 287

(Drawing 143F020)

The main landing gear vee-brace/main strut pivot joint is attached to the fuselage by the fitting at Station 287. This fitting also splices the space truss lower cluster to the aft lower longeron and bulkhead at Fuselage Station 287. Loads applied by the main landing gear are obtained from H. W. Loud Machine Works, Inc., final stress analysis report for the main landing gear. The loads applied by the space truss members are obtained from Volume II, , Section XI. Vertical loads are reacted by bulkhead 287 side member and the unbalanced moment is reacted by a couple in the z-y plane. Longitudinal loads are reacted by the aft longeron and two stiffeners on the lower shear web. The distribution to these three members is based on estimates of the relative stiffnesses determined in the preliminary analysis. Unbalanced moment in the x-y plane is reacted by a couple in bulkhead 287 and 296.5 lower flanges. The unbalanced moment in the x-z plane is reacted by kick loads, K_1 and K_2. An overlap assumption of 75% of M_y taken each by K_1 and K_2 is used.

Tail-down, spring-back landing (landing condition 6 or fuselage loading condition L-16) is the critical condition.

*Loads Applied to Pivot Lugs

Lateral load = 1.5 (-18677) = -28000# (acting inboard)

Loud Machine Works loads are in the vee-brace/main strut plane, which is 10.5° from vertical.

*Ref. Loud Machine Works Report No. 1510L00, Page 166.

AT INBD LUG:

$V = 1.5 \times 21679 \cos 10.5° = 31950$ #

$D = 1.5 \times 21679 \sin 10.5° = 5920$ #

AT OUTB'D LUG:

$V = 1.5 \times 12741 \cos 10.5° = 18800$ #

$D = 1.5 \times 12741 \sin 10.5° = 3480$ #

LOADS APPLIED BY SPACE TRUSS MEMBERS

(REF. REPT 63 B 131, SECT. XI)

MEMBER	LIMIT LOAD	ULT. LOAD
25-28	-25521 #	-38282 #
26-28	-1114	-1671
8-28	-10573	-15860
9-28	450	675

X-Y-Z COMPONENTS ARE DETERMINED FROM DIRECTION COSINES GIVEN IN REPT. 63 B 131

MEMBER 25-28 (LWR. LONG.)

$X = .99916 \times -38282 = -38280$ #
$Y = -.04106 \times -38282 = 1570$ #
$Z = 0 = 0$

MEMBER 26-28 (LWR. "X" BRACE)

$X = .8719 \times -1671 = -1460$ #
$Y = .4897 \times -1671 = -820$ #
$Z = 0 = 0$

MAIN LANDING GEAR SUPPORT FITTING-STATION 287

LOADS APPLIED BY SPACE TRUSS MEMBERS

MEMBER 8-28 (SIDE DIAGONAL)

$X = .5318 \times -15860 = -8440$ #
$Y = -.0694 \times -15860 = 1100$ #
$Z = -.844 \times -15860 = 13400$ #

MEMBER 9-28 (CROSS DIAGONAL)

$X = .463 \times 675 = 310$ #
$Y = .2674 \times 675 = 190$ #
$Z = -.845 \times 675 = -570$ #

COMPUTATION OF REACTIONS

M_{x-z} (ABOUT INTERSECTION FS 287 ∮ WL 96.11) = 50750 × 1 − 12830 × 1.6 + 8130 × 1.93 − 9400 × .11 − 38280 × .61 − 1460 × .985 = 20100 "#

$K_1 = .75 \times \frac{20100}{9.51} = 1583$ #

$K_2 = .75 \times \frac{20100}{9.5} = 1588$ #

Σ SIDE FORCES = 0

REACTION = 28000 + 1570 + 1280 − 820 = 30030 #

Σ VERTICAL FORCES = 0

REACTION = 31950 + 18800 + 1590 − 2 × 6415 = 39510 #

Σ M_{z-y} (ABOUT BL 20.16 / WL 96.11 INTERSECTION) =

39510 × 2.41 + (6415 − 18800).38 + (31950 − 6415)2.54
− 1590 × 2.25 + 1570 × .61 + 28000 × .11 − 820 × .985
− 1280 × 1.93 = 152500 "#

MAIN LANDING GEAR SUPPORT FITTING-STATION 287

COMPUTATION OF REACTIONS

REACTING M_{z-y} COUPLE $= \dfrac{152500}{8.81} = 17300$ #

SHEAR FLOW APPLIED BY SIDE SKIN = 869 #/IN.
(REF. PART I, PG. 115)

LOAD APPLIED BY SKIN = 869 (296.5 − 287) = 8250 #

Σ HORIZONTAL FORCES = 0

REACTION = 38280 + 9400 + 8130 + 1460 − 8250 − 1580
= 47440 #

THIS REACTION IS DISTRIBUTED TO LOWER LONGERON, BL 16.5 MEMBER & WEB SHEAR ACCORDING TO FOLLOWING PROPORTION DETERMINED IN ORIGINAL DETAIL STRESS ANALYSIS;

LOWER LONGERON	57%	.57 × 47440 =	27000 #
B.L. 16.5 MEMBER	28%	.28 × 47440 =	13280 #
INBOARD SHEAR	15%	.15 × 47440 =	7110 #
		(7110/7.7) =	924 #/IN.

ΣM_{x-y} (ABOUT BL 20.16/FS 287 INTERSECTION) =

$-(23205 + 3480).38 + (23205 - 5920)2.54 + 1460 \times 4.16$
$- 1580 \times 1.08 + 1570 \times 3.25 + 1280 \times 1.6 + 28000 \times 1$
$- 920 \times .2 + 869 \times 9.5 \times 3.75 + 27000 \times 2.25 - 13280 \times 3.66$
$- 7110 \times 5.37 = 77950$ "#

REACTING M_{x-y} COUPLE $= \dfrac{77950}{7.7} = 10120$ #

MAIN LANDING GEAR DRAG STRUT SUPPORT STRUCTURE

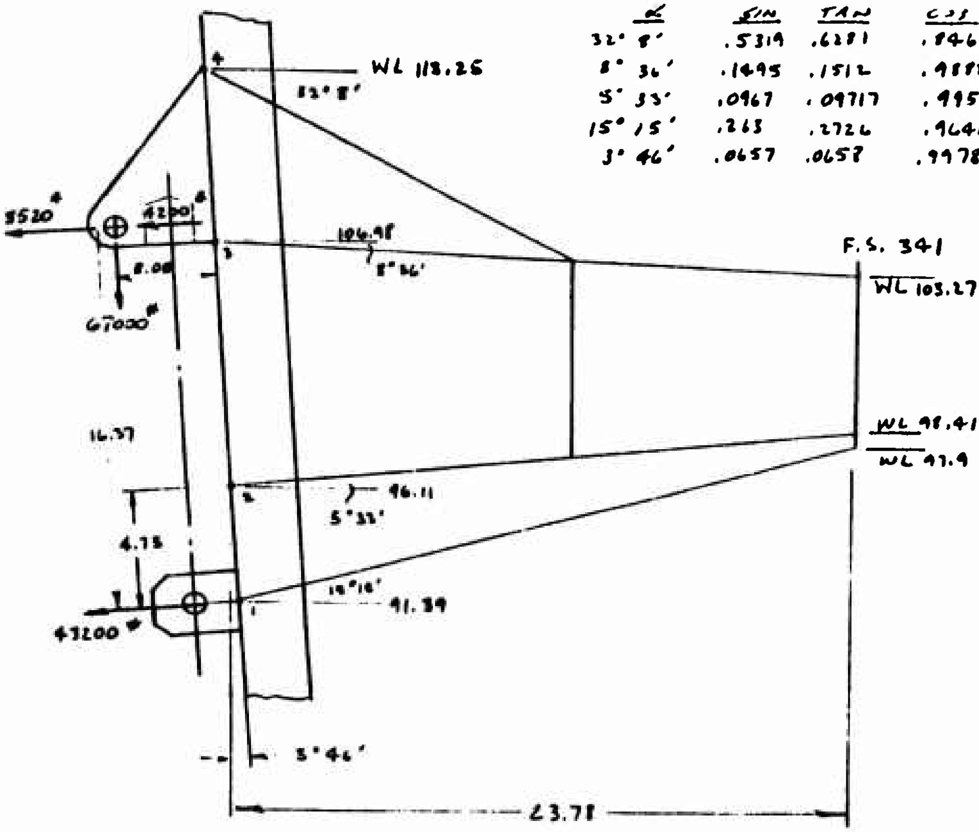
(Drawings 143F118 and 143F065)

The aft end of the drag strut vee-brace is supported by 143F118 fitting, which is attached to bulkhead at Fuselage Station 317.2, and the 143F130 backup structure. Vertical loads are reacted by bulkheads at Fuselage Station 317.2 and Fuselage Station 341, and the longitudinal load is reacted by the lower shear web.

The critical condition is a two-wheel, tail-down, spring-back landing. Loads applied to the support fitting by the drag brace are computed on Page 74 .

MAIN LANDING GEAR DRAG STRUT ATTACHMENT FITTING

α	SIN	TAN	COS
32° 8'	.5319	.6281	.8468
8° 36'	.1495	.1512	.9888
5° 33'	.0967	.09717	.9953
15° 15'	.263	.2726	.9648
3° 46'	.0657	.0658	.9978

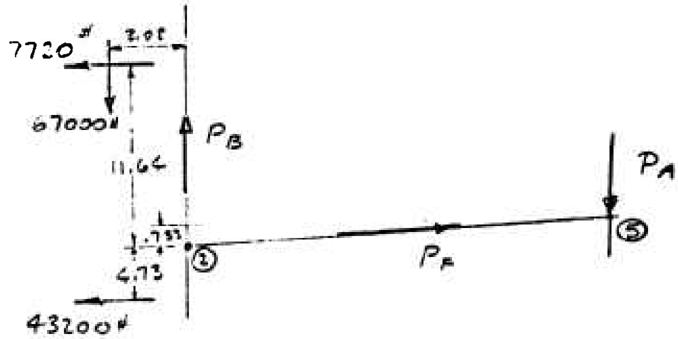


PT.	F.S.
1	317.52
2	317.216
3	316.5
4	316.085

ULT. LOADS APPLIED TO FITTING
TAIL-DOWN SPRING-BACK COND.

MAIN LANDING GEAR DRAG STRUT ATTACHMENT FITTING

EXTERNAL LOADS ~ FTG. + BACK-UP STRUCTURE



$\Sigma M_2 = 0$

$$23.78\ P_A = 67000 \times 3.08 + 7720 \times 11.64 - 45200 \times 4.75$$

$$P_A = \underline{3845}\ \#$$

$$d = 23.78 \cos 3°46' + 2.3 \sin 3°46' = 23.85$$

$\Sigma M_5 = 0$

$$23.85\ P_B = 67000(23.85 + 3.08) + 7720 \times 10.907 - 43200 \times 5.463$$

$$P_B = \underline{69150}\ \#$$

$\Sigma H = 0$

$$P_F \cos 5°33' = (43200 + 7720) \cos 3°46' + (69150 - 67000) \sin 3°46'$$

$$P_F = 51300\ \#$$

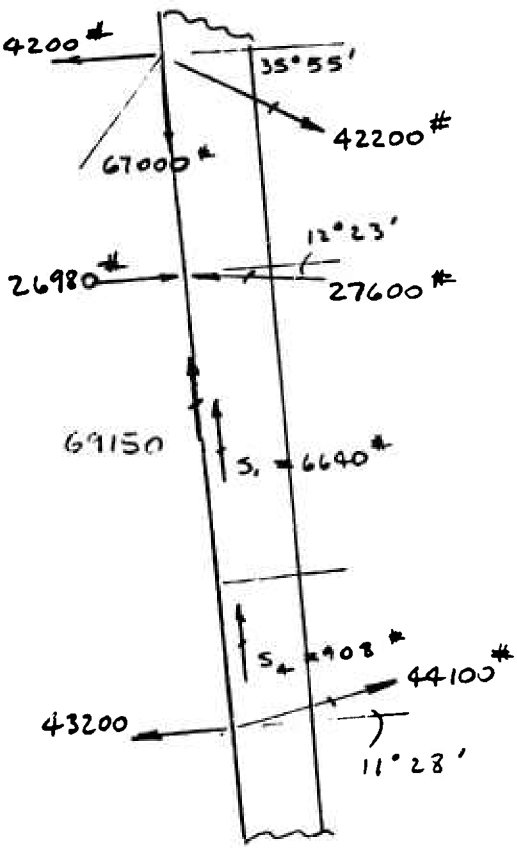
CHECK $\Sigma V = 0$

$$50920 \sin 3°46' + 3845 = 2150 \cos 3°46' + 51300 \sin 5°33'$$

$$7155 = 7105 \quad \text{OK}$$

MAIN LANDING GEAR DRAG STRUT ATTACHMENT FITTING

FITTING "FREE BODY"



$$\frac{67000 \times 3.08 + 7220 \times .92}{6.24} = 34200^{\#}$$

$$\frac{67000 \times 3.08 - 7220 \times 5.32}{6.24} = 26980^{\#}$$

ASSUME LOADS APPLIED BY UPR. & LWR. LUGS ARE REACTED DIRECTLY BY BACK-UP MEMBERS, (NO BENDING ON FTG.)

$$\frac{34200}{\cos 35°55'} = 42200^{\#}$$

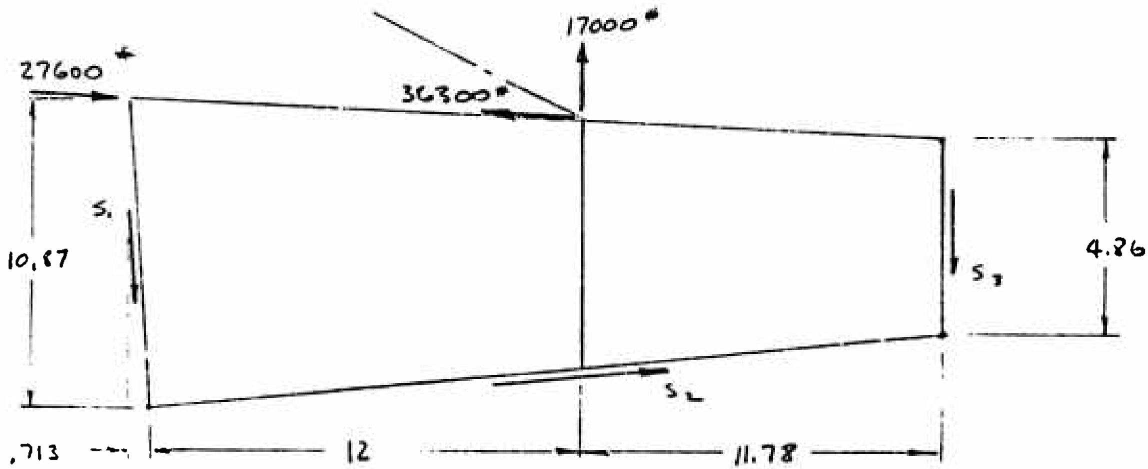
$$\frac{26980}{\cos 12°23'} = 27600^{\#}$$

$$\frac{43200}{\cos 11°28'} = 44100^{\#}$$

MAIN LANDING GEAR DRAG STRUT ATTACHMENT FITTING

UPPER WEB

$36300 - 27600 = 8700^{\#}$



$$23.85\, S_1 + (36300 - 27600)\, 4.86 \cos 8°36' - 17000 \times 11.78 = 0$$

$$S_1 = 6640^{\#}$$

$$(23.85 + 4.86 \sin 3°46')\,6640 - 17000 \times 11.78 + S_2 \times 4.86 \cos 5°33'$$

$$S_2 = 8270^{\#}$$

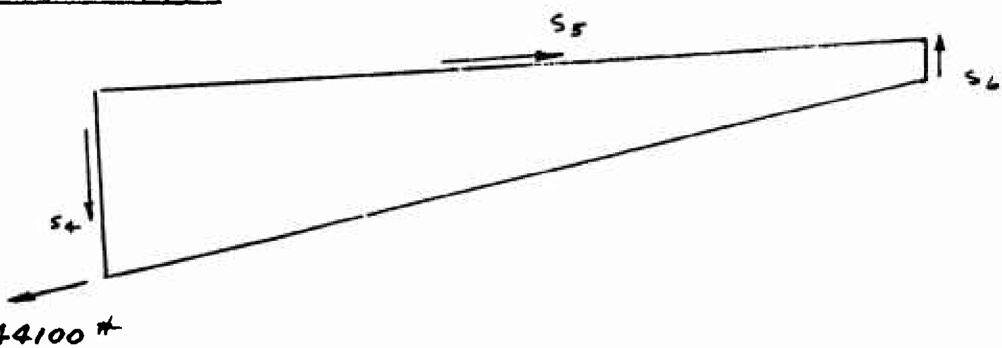
$$23.78\, S_3 - 17000 \times 12 - 8700\,(\overset{10.62}{10.87 \cos 8°36' - .713 \sin 8°36'})$$

$$S_3 = 12480^{\#}$$

CHECK: ΣV

	↑	↓	
	17000	6640	
8700 sin 8°36′ =	1300	12480	
8270 sin 5°33′ =	800		
	19100	19120	OK

LOWER WEB



$$23.85\, S_4 - 44100 \times .51 \cos 15°15'$$

$$S_4 = 908 \; \#$$

$$.51 \cos 5°33' \times S_5 = 908\,(23.85 - .51 \sin 3°46')$$

$$S_5 = 42550 \; \#$$

$$23.78\, S_6 - 44100 \times 4.73 \cos (15°15' - 3°46') = 0$$

$$S_6 = 8600 \; \#$$

CHECK: ΣV

↑		↓	
42550 sin 5°33' =	4110	44100 sin 15°15' =	11600
	8600		908
	12710		12508

O.K.

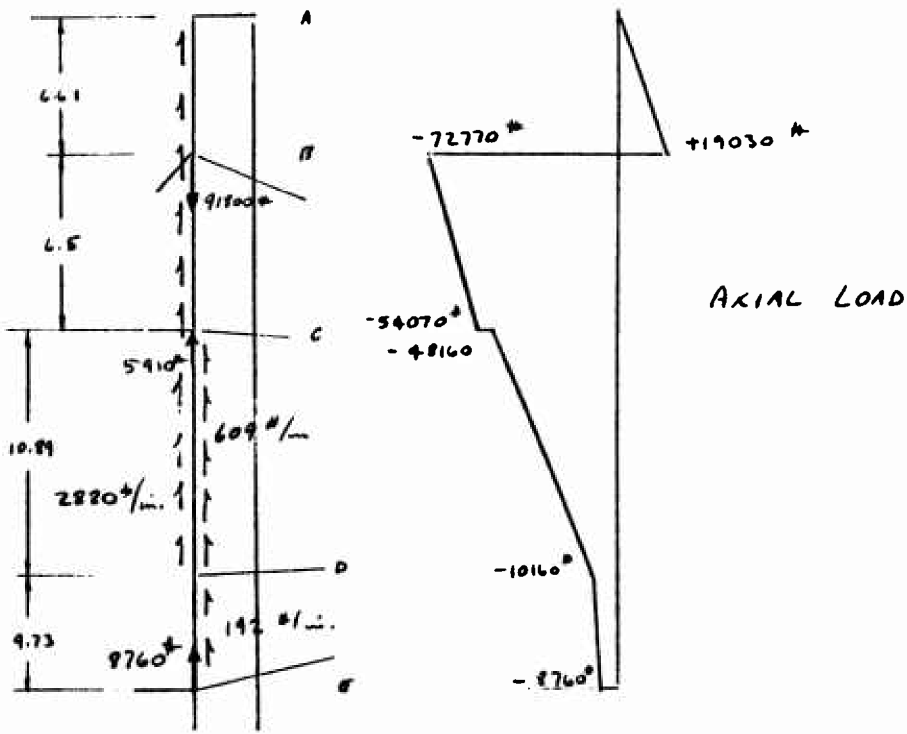
MAIN LANDING GEAR DRAG STRUT ATTACHMENT FITTING

FITTING LOADS

BULKHEAD SHEAR = 69150# $\quad q = 69150/24 = 2880$ #/in.

UPR WEB $q = 6640/10.89 = 609$ #/in.

LWR WEB $q = 908/4.73 = 192$ #/in.



$67000 + 42200 \sin 35°55' = 91800$#

$44100 \sin 11°28' = 8760$#

$27600 \sin 12°25' = 5910$#

MAIN LANDING GEAR MODE CHANGE ACTUATOR SUPPORT FITTING

(Drawing 143F129)

The lower end of the mode change actuator is attached to fitting 143F129, which is supported by the keel and fitting 143F065. In addition to changing the wheel position, the actuator acts as a fixed compression link in gear aft landing conditions. The actuator reacts compression loads in the drag brace when the attaching slider is in the up position. The critical condition is No. 27 - 9200# G.W., gear aft, two point level springback. The actuator load is found by equating the vertical component to the vertical component of the drag brace loads.

Limit Drag Brace Load = 9462#

Z Comp. Drag Brace Load = 7325#

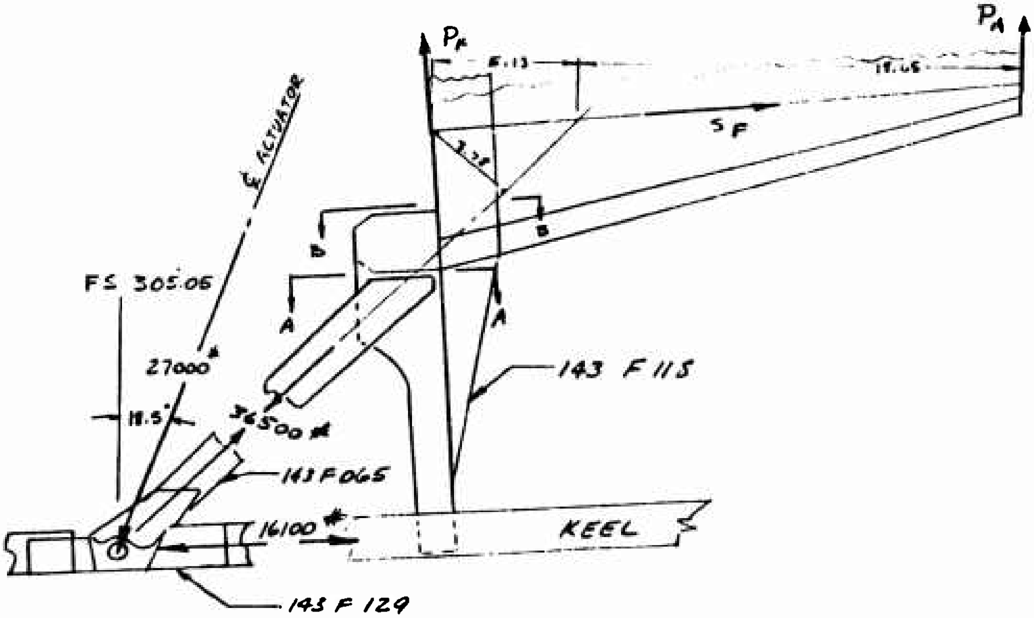
(Ref. Report No. 131, "LANDING GEAR CRITERIA, GROUND LOADS AND REACTIONS", Page 131.)

$$\text{Ultimate Actuator Load} = \frac{2 \times 7325}{\cos 18.5^\circ} \times 1.5 = 23100\# \text{ (Comp.)}$$

The actuator has been designed for an ultimate compressive load of 27000# (Ref. Drawing SCD-L0006). Therefore, the backup structure is also designed for this conservative load.

GEAR POSITIONING ACTUATOR SUPPORT STRUCTURE

ULT ACT. LOAD = 27000# (REF. SCD-L0006)



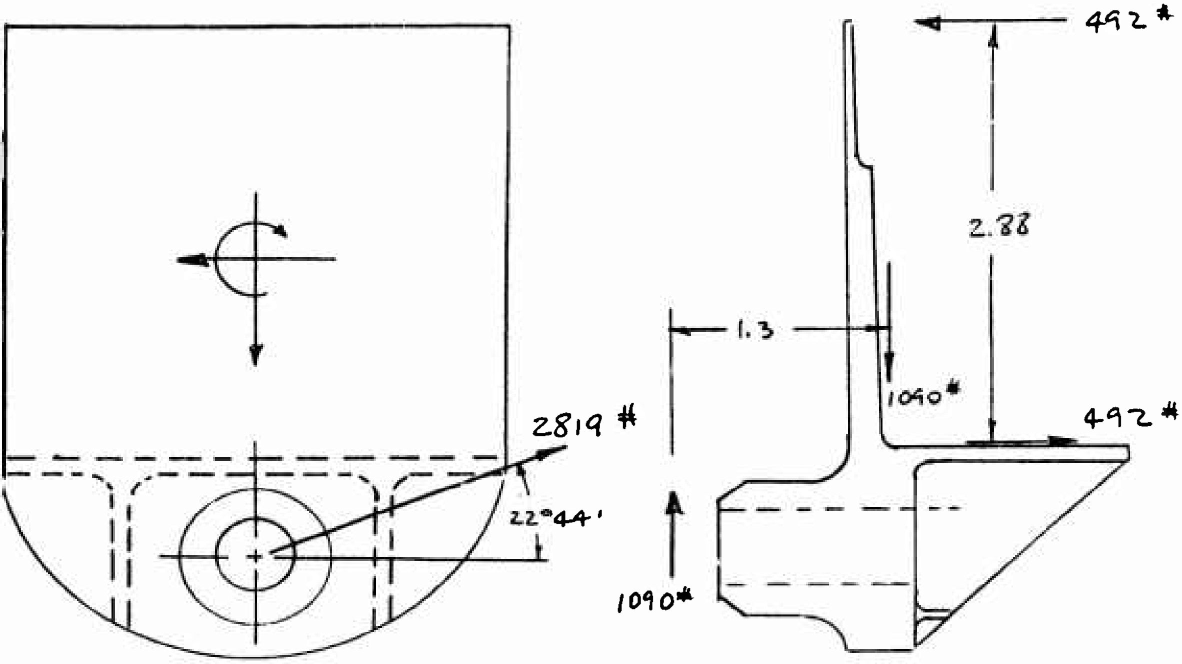
$23.78\ P_A = 36500 \times 3.78$ $\qquad P_A = 5800^{\#}$

$5.13\ P_F = 18.65 \times 5800$ $\qquad P_F = 21050^{\#}$

BY GRAPHICS; $\qquad S_F = 26000^{\#}$

FLAP INBOARD HINGE FITTING

(Drawing 143F180)



NBD HINGE LOAD = 2819 # (REF. REPT. 63B118 P. 6)

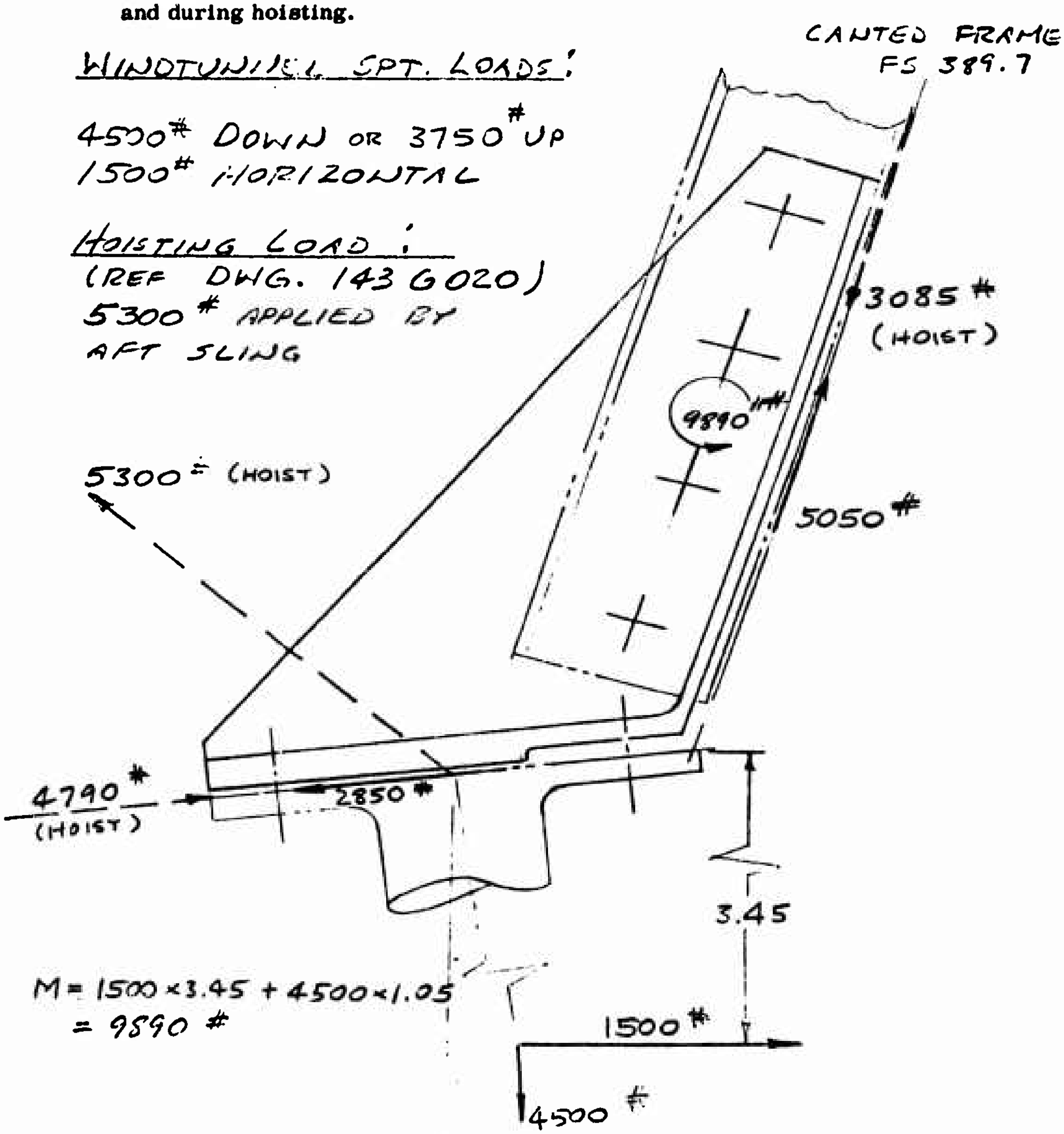
VERT. COMP. = 2819 SIN 22°44' = 1090 #

LONGITUDNAL COMP. = 2819 COS 22°44' = 2600 #

JACK PAD FITTING

(Drawing 143F061)

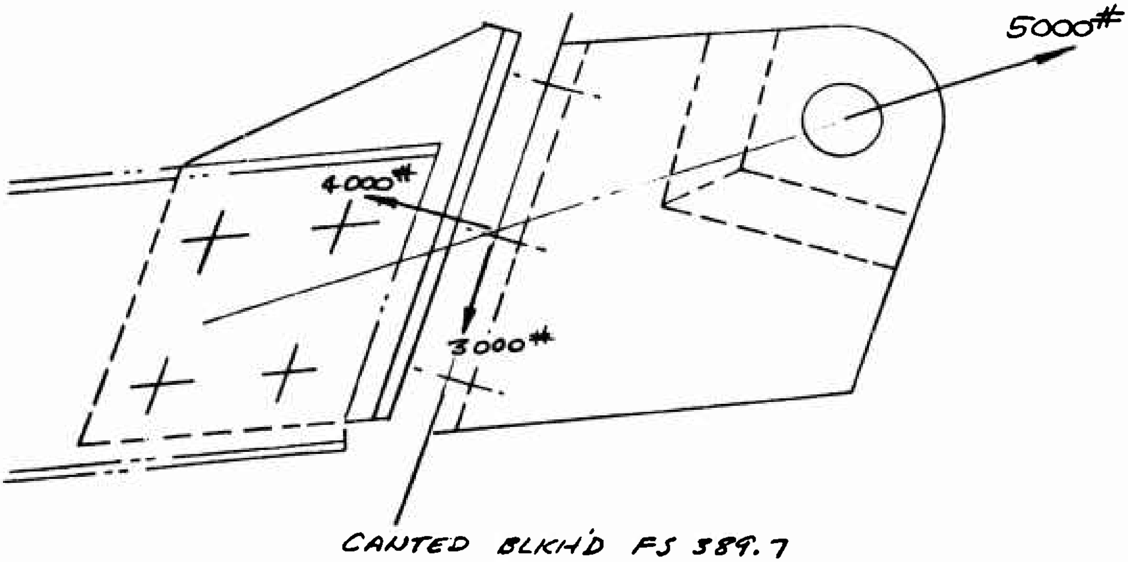
The jack pad fitting is attached to the canted frame @ Fuselage Station 389.7. Critical loads are applied by the airplane wind tunnel supports, and during hoisting.



THRUST SPOILER ACTUATOR SUPPORT

(Drawing 143F166)

Ultimate Actuator Load = 5000# (capacity)

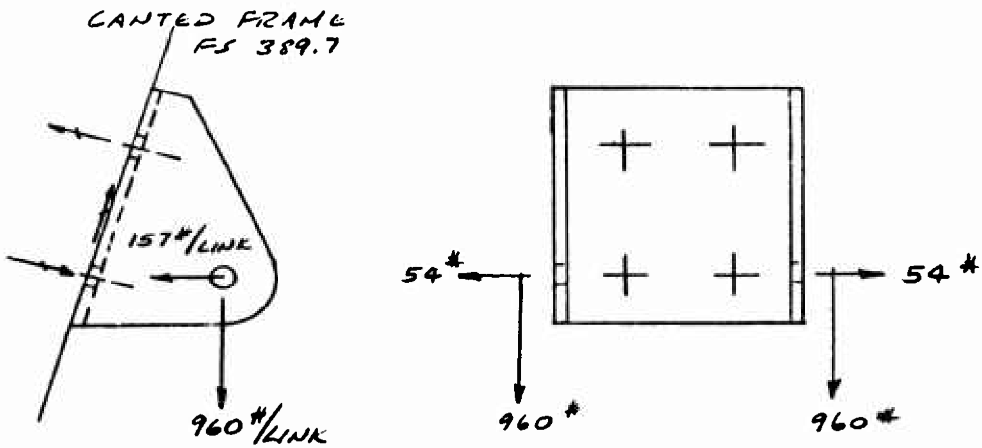


TAILPIPE AFT SUPPORT

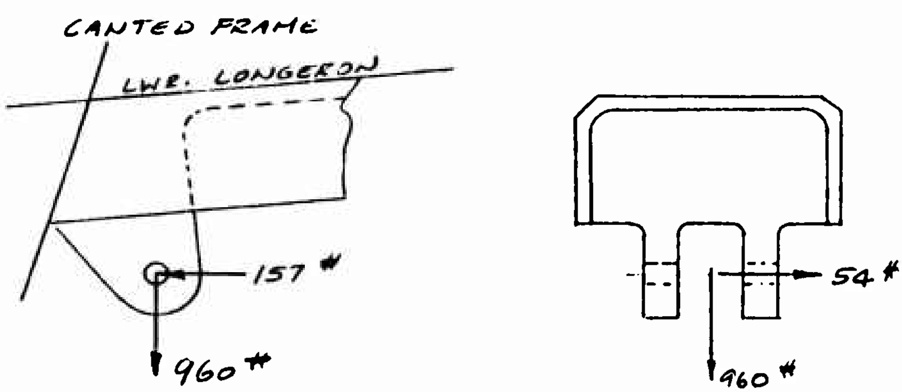
CENTRAL FITTING (143 F 116)

ULT. LINK LOAD = 975# (REF. REPT. 63 B 131)

$L_x = .1609 \times 975 = 157^{\#}$
$L_y = .0557 \times 975 = 54^{\#}$
$L_z = .9554 \times 975 = 960^{\#}$



OUTBOARD FITTING (143 F 068)



PARACHUTE ATTACHMENT STRUCTURE

The parachute attachment structure and storage canister is designed to accommodate two types of parachutes: a 6' diameter, 12 gore, ribless guide surface parachute used for deceleration from high speed or spin recovery, and a 12.75' nominal diameter ring slot parachute used for deceleration during landing of the 12500# G.W. configuration or spin recovery in a reefed condition* (Ref. Drawing SCD-Q-0002). The maximum load is applied by the smaller parachute during high speed deployment. Loads occurring during spin recovery are also considered, because the load can be applied at large angles relative to the airplane longitudinal axis.

<u>High Speed Deceleration Condition:</u>

Ultimate Load = 25000# (g = 850 psf)

<u>Spin Recovery Condition:</u>

Ultimate Load = 3220# (g = 110 psf)

Load is applied 30° in vertical plane or 21° in horizontal plane.

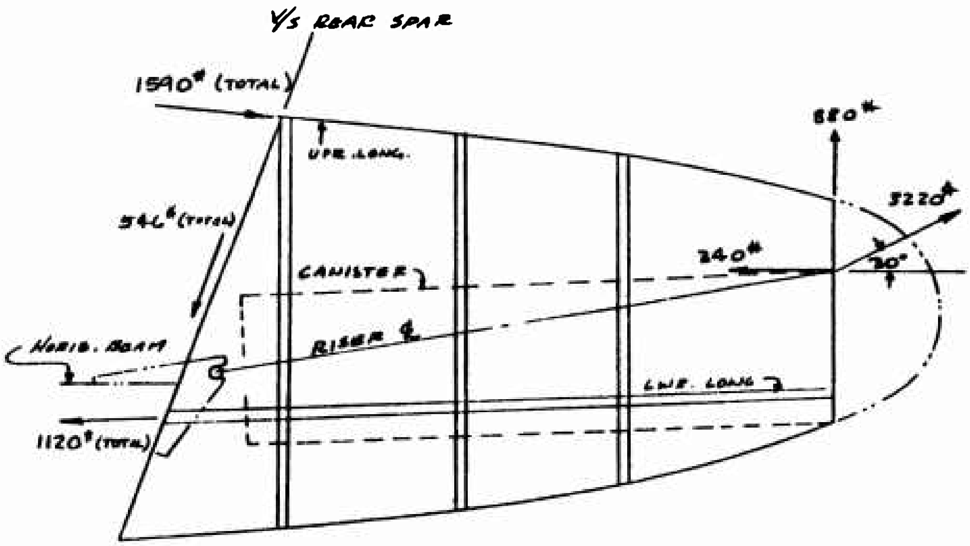
*Equivalent drag area = 43.2 sq. ft. in reefed condition.

PARACHUTE ATTACHMENT STRUCTURE

Loads Applied to Tail Cone (Drawing 143F064)

The parachute is attached to the fuselage by a fitting located forward of the tail cone. However, loads are applied to the tail cone by the riser when the angle of the parachute load line is sufficient to cause the riser to bear against the tail cone aft frame. Critical loads applied during spin recovery and reactions at the tail cone splice are shown below.

Riser 30° up in Vertical Plane

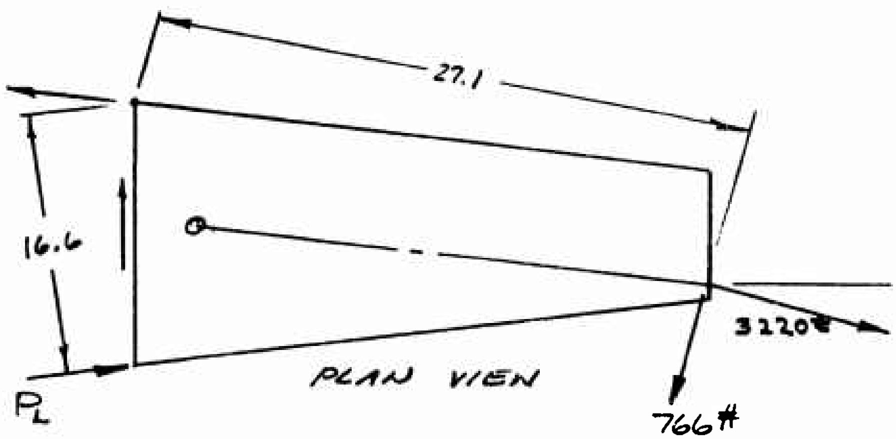


SIDE VIEW

PARACHUTE ATTACHMENT STRUCTURE

Loads Applied to Tail Cone

Riser at 21° in Horizontal Plane

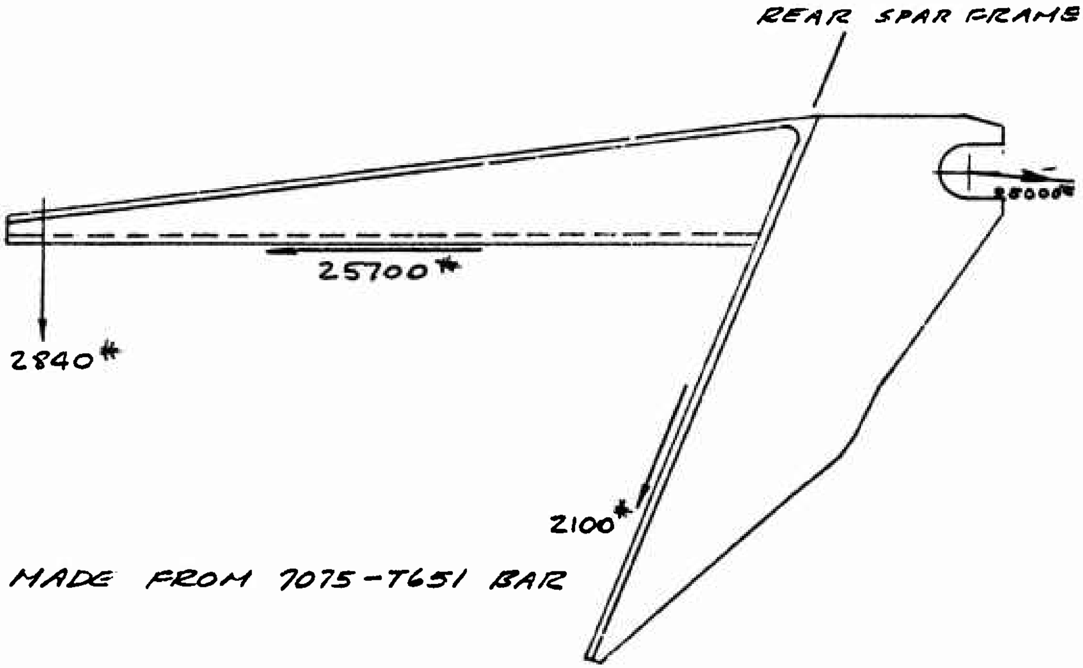


CRITICAL LOWER LONGERON LOAD = P_L

$$P_L = \frac{766 \times 27.1}{16.6} = 1250\#$$

PARACHUTE ATTACHMENT STRUCTURE

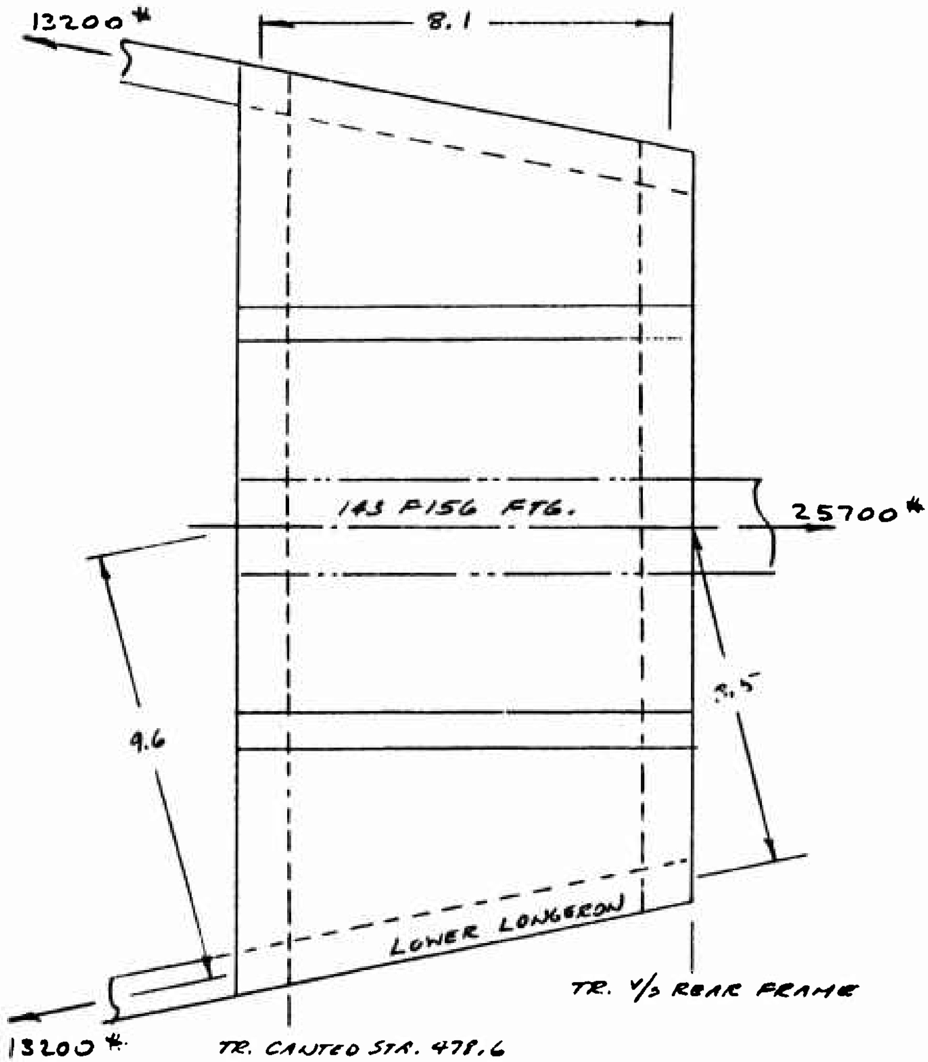
Parachute Attachment Fitting (Drawing 143F156)



LOADS SHOWN FOR RISER LOAD APPLIED AT MAX. DOWN ANGLE TO GIVE LARGEST KICK LOAD AT FWD SUPPORT (2840#).

PARACHUTE ATTACHMENT STRUCTURE

Fitting Support Beam (Drawing 143F134)



FITTING SUPPORT BEAM

THE HORIZONTAL BEAM SHEARS THE 25700# LOAD APPLIED BY THE ATTACHMENT FITTING TO THE LOWER LONGERONS.

$$\text{MAX. SHEAR FLOW} = \frac{25700}{2 \times 8.1} = 1587 \ \#/\text{IN.}$$

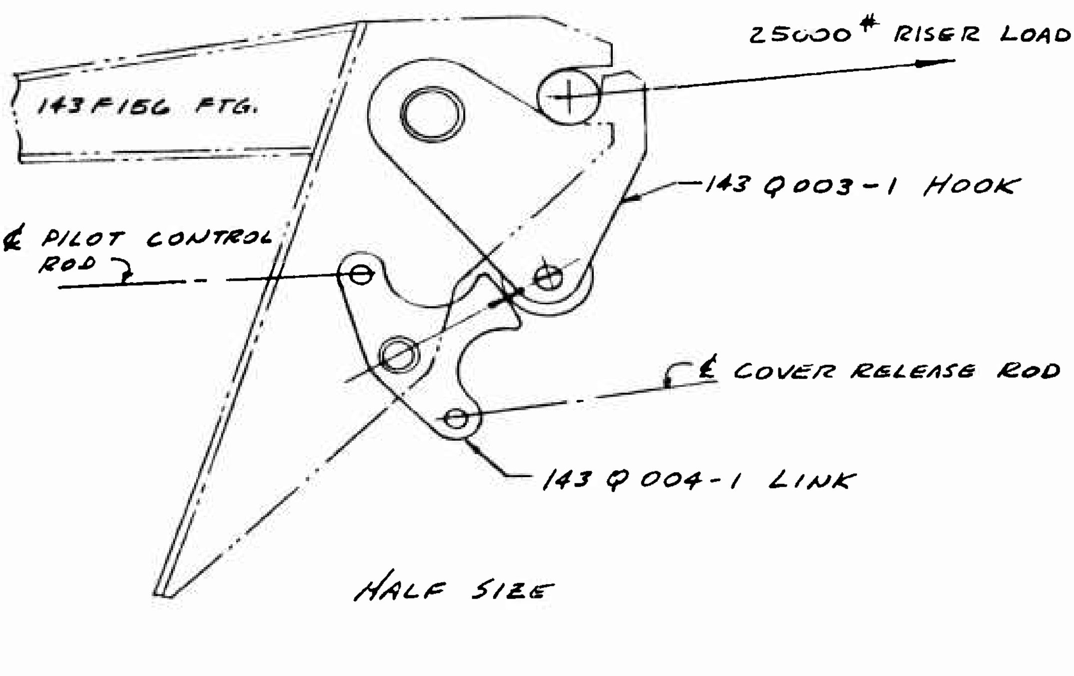
$$\text{FWD. CAP LOAD} = \frac{13200 \times 8.5}{8.1} = -13850\#$$

$$\text{AFT CAP LOAD} = \frac{13200 \times 9.6}{8.1} = +15650\#$$

PARACHUTE ATTACHMENT STRUCTURE

Parachute Release Mechanism (Drawing 143Q001)

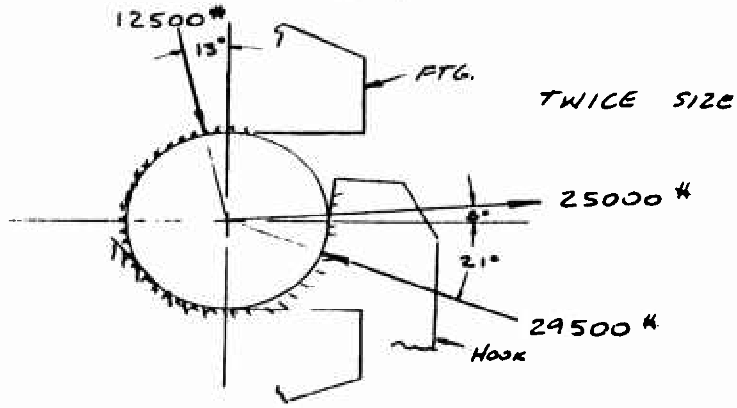
The parachute riser is secured to the attachment fitting (143F156) by 143Q003-1 hook which is lock-wired in the UP position after installing the parachute. Initial movement of chute control lever by the pilot rotates 143Q004-1 link to an intermediate position, which locks the hook in the UP position, and also releases the canister cover allowing the chute to be ejected. Additional movement of the control level rotates the link to the full over position, which allows the chute load to break the hook lock-wire. The hook then rotates down and the chute is released. Loads are shown below for the intermediate position where the link locks the hook. Free-body load diagrams follow.



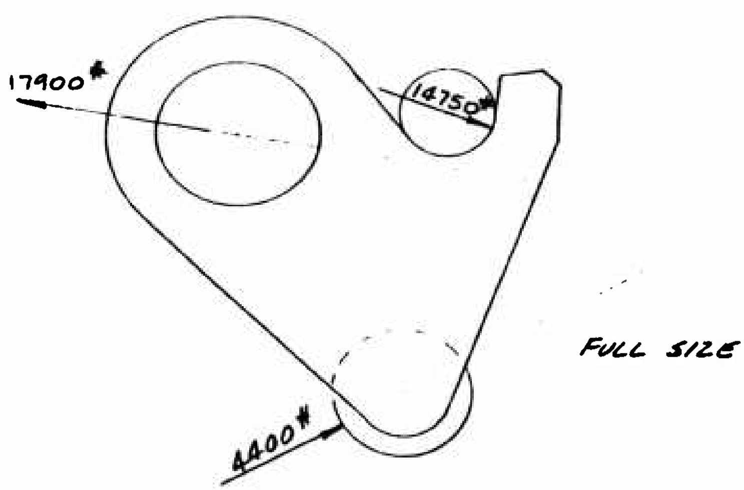
PARACHUTE ATTACHMENT STRUCTURE

Release Mechanism

RISER SPOOL



143 Q 003-1 RETAINER HOOK
(LOADS PER SIDE)



PARACHUTE ATTACHMENT STRUCTURE

Release Mechanism

143Q004-1 Link